Ontario Ministry of Consumer and Commercial Relations

DUNLOP FARROW AITKEN
architects
engineers

A STUDY OF THE ADDITIONAL REQUIREMENTS FOR HIGH COMMERCIAL BUILDINGS

PREPARED FOR
THE BUILDING CODE BRANCH
TECHNICAL STANDARDS DIVISION
MINISTRY OF CONSUMER AND
COMMERCIAL RELATIONS
PROVINCE OF ONTARIO

DUNLOP
FARROW
AITKEN

450 FRONT STREET WEST
TORONTO, ONTARIO (416) 596-6666
M5V 1B6

architects
engineers

October 27, 1982.

Ministry of Consumer and
Commercial Relations,
Building Code Branch,
3300 Bloor Street West,
Etobicoke, Ontario. M8X 2X2

Attention: Mr. G. Adams,
Director

Dear Sir:

We are pleased to submit the results of our study of the additional requirements for life safety in high commercial buildings.

At this time we wish to thank the staff of the Building Code Branch, the members of the steering committee, and the many individuals and organizations interviewed for their advice and guidance.

We feel the Ministry is to be congratulated for undertaking what we understand to be the first comprehensive review of the use and application of the measures. The subject is both relevant and pertinant; and we trust our findings will contribute to any further examination.

Yours very truly,

DUNLOP . FARROW . AITKEN

Christopher T. Fillingham, M.R.A.I.C.

CTF:rmh

Partners
D.T.Dunlop, B.Arch., FRAIC
G.B.P.Farrow, B. Arch., MRAIC
W.D.Aitken, B.A.Sc., P.Eng.
C.W.Cansfield, B.Arch., MRAIC

Associates
R.M.Holt
R.M.Rimas, P.Eng.
D.W.Pinkney, CSC, RSW
H.B.Lowry, RA
N.S.Crone, MRAIC
G.E.Fraser, MRAIC
C.T.Fillingham, MRAIC
G.K.Okamura, MRAIC
J.B.Wilkinson, MRAIC

THE BUILDING CODE BRANCH OF

MINISTRY OF CONSUMER & COMMERCIAL RELATIONS

PROVINCE OF ONTARIO

ADDITIONAL REQUIREMENTS

FOR

HIGH COMMERCIAL BUILDINGS

DUNLOP
FARROW
AITKEN

architects
engineers

Consultants:

Rolf Jensen & Assoc. Ltd.
B. Clemmensen & Assoc. Ltd.

October, 1982

TABLE OF CONTENTS

	Page No.
SUMMARY	
INTRODUCTION	
- Terms of Reference	1
- Study Method	2
EXISTING REQUIREMENTS	
- Background	3
- Fire Experience Record	7
- Frequency of Use	9
- Survey of Smoke Control Systems	10
- Sprinkler Requirement Survey	11
- Use and Application	12
- Measure 'A' Fully Sprinklered Building	16
- Measures 'B' and 'C' Open Corridor Access to Stairs/Elevators	22
- Measures 'D' and 'E' Protected Vestibule Access to Stairs/Elevators	29
- Measures 'F' and 'G' Pressurized Stair & Elevator Shafts	38
- Measure 'H' Building Fully Pressurized	47
- Measures 'I' and 'J' Partially Pressurized Building	55
- Measure 'K' Vertically Divided Building	62
- Measure 'L' Areas of Refuge	69
- Measure 'M' Building with Balconies	76
- Summary Description of Smoke Control Measures Chart	
- Evaluation of Measures	80
- Cost Comparison of Measures	81

TABLE OF CONTENTS

	Page No.
CONCLUSIONS	
- Limit the Size of the Fire	85
- Detect the Fire	89
- Certain Smoke Control Measures	90
- The Human Factor	93
RECOMMENDATIONS	
- General	95
- Smoke Control in Groups D & E (Office and Retail Buildings)	97
- Sprinklering Subsidiary Occupancies in Group C Hotels	104
- Smoke Control in Group C Hotel Buildings	106
- Subsidiary Occupancy	108
- Equivalent Measures	110
- Heating of Outside Air	112
- Separation of Buildings	113
- Commissioning	114
- Smoke Shaft Venting	117
APPENDICES	
- Appendix 'A' Fire Experience Statistics Province of Ontario (1976 - 1980)	
- Appendix 'B' Fire Experience Statistics Building Owners and Managers Association of North America (1981)	

SUMMARY

SUMMARY

In 1981, the Building Code Branch of the Ministry of Consumer and Commercial Relations commissioned this Study of the Additional Requirements for Life Safety in High Buildings as they apply to Business and Personal Service, Mercantile, and Hotel occupancies.

Very broad terms of reference were agreed upon for the study in order to provide a broad assessment of all the factors impacting on the requirements and their use and experience.

The Terms of Reference for the study were:

- Study the building requirements of Subsection 3.2.6. of the National Building Code 1980.

- Consider methods by which requirements to limit the danger from exposure to smoke may be implemented, in new commercial buildings such as hotels, office buildings, and retail outlets. The A.C.N.B.C. booklet "Measures for Fire Safety in High Buildings 1980" shall be considered.

- Determine an estimate of cost of incorporating the requirements of Subsection 3.2.6., noted in the second item above, in new commercial buildings.

- Establish a cost-benefit relationship between any increase in cost and the resultant increase in fire safety in new commercial buildings where smoke limitation measures are provided.

- Make recommendations about the application of the requirements of Subsection 3.2.6., as noted in the second item above, to new commercial buildings.

SUMMARY

The methods of inquiry included extensive interviews with user groups including the fire service, building owners, designers, researchers, and approving authorities. Pertinent literature and studies originating in Canada and internationally were read. Data were assessed in light of the wide experience in the field on the part of the study team and its steering committee.

The study undertook to examine and collate fire experience statistics, examine the existing requirements, study the use experience of the existing requirements, and make recommendations and identify the economic impact.

The study's findings are as follows:

- Statistics indicate that the life safety record in the occupancies studied is enviable when compared to other building types.
- No fire incident in buildings incorporating the additional requirements could be found by the study team.
- Measures that are readily adaptable to the inherent building design are utilized.
- There are concerns among major user groups that particular measures having a history of re-testing will perform as designed.
- The more reliable the measure the more expensive it is when compared to other measures.
- A survey of the measures being installed across Canada indicates an increasing trend to sprinkler buildings of these occupancies whether on a voluntary selection or mandated.
- The more reliable measures are less dependent on complex control of mechanical components which, for a variety of reasons including the human element, have a record of failure in testing programmes.

SUMMARY

In addition, the study has drawn several fundamental conclusions of major considerations affecting further use of the measures:

- The most effective method of limiting the danger to the occupants of high commercial buildings is to limit the size of the fire. Limiting the size of the fire either by means of effective compartmentation such as the rooms or suites in hotels or a direct suppression system such as sprinklers has a major impact on reducing the amount of smoke produced which may then travel through all parts of the building.

- Immediate notification of the fire department and occupants of a potential fire is paramount. One common thread, when one reads the reports of multiple life loss fires in high commercial buildings, is the failure of notification. All fire experts appear to agree that the critical element in a fire emergency is the reduction of the time from when the fire starts to the time when water can be put on it.

- In our study of the existing requirements we were able to identify problems perceived by the various user groups against a set of criteria established to provide a broad background of comment. Our evaluation of that criteria shows that a number of the measures cannot be expected to reliably achieve their designed goals.

- As we adopt more stringent fire protection systems for high rise structures (and as that goes for any structure), we must not overlook the human factor. We are not suggesting that all human reactions are negative in respect to anticipated action but when recommending any measure for life safety the human factor regarding their intended action and response must be considered paramount.

SUMMARY

Our recommendations are tailored to specific problems identified in our study of the requirements and to the fundamental conclusions we have drawn. The intent of the recommendations is to:

- minimize the intention of a conscious decision of the occupant
- minimize the number of measures for the fire fighter
- maximize the opportunity for an engineered equivalency
- minimize the impact of the changing building use and tenancy on the measure's reliability
- maximize the cost effectiveness of the requirements for the benefit of the "end user"

Our recommendations are:

- High buildings of Groups D and E occupancy should be fully sprinklered and certain requirements should be relaxed.
- All areas, other than the residential area of a hotel occupancy should be sprinklered.
- High buildings of Group C hotel occupancy should be partially sprinklered or incorporate the balcony or vented vestibule measure for smoke control.
- Equivalent measures to the prescriptive measures recommended should be subject to criteria that define clearly the concerns of reliability addressed in the study.
- The Building Code should contain guidelines for the commissioning of life safety systems.
- Specific requirements described in the body of the study should be clarified.

INTRODUCTION

TERMS OF REFERENCE

In 1981, the Building Code Branch of the Ministry of Consumer and Commercial Relations commissioned this Study of the Subsection 3.2.6. "Additional Requirements for High Buildings" as they apply to Business and Personal Service, Mercantile, and Hotel occupancies.

The Terms of Reference are:

- Study the building requirements of Subsection 3.2.6. of the National Building Code 1980.

- Consider methods by which requirements to limit the danger from exposure to smoke may be implemented, in new commercial buildings such as hotels, office buildings, and retail outlets. The ACNBC booklet "Measures for Fire Safety in High Buildings 1980" shall be considered.

- Determine an estimate of cost of incorporating the requirements of Subsection 3.2.6., noted in paragraph 2 above, in new commercial buildings.

- Establish a cost-benefit relationship between any increase in cost and the resultant increase in fire safety in new commercial buildings where smoke limitation measures are provided.

- Make recommendations about the application of the requirements of Subsection 3.2.6., as noted in paragraph 2 above, to new commercial buildings.

STUDY METHOD

The Study consisted of five tasks:

1. Examine and collate fire experience statistics

   Without initiating a statistics gathering study, we examined the available data for Ontario in order to provide a summary relating to the occupancy types under study.

2. Examine the existing requirements

   The purpose of this task was to examine and report the current status of regulations regarding life safety in high buildings of the occupancy types under study.

3. Study the use experience of the existing requirements

   The frequency of use of the various smoke control measures was summarized from existing surveys.

   In order to evaluate the various measures, interviews were conducted with owners, fire fighters, designers and authorities.

4. Make recommendations

   Conclusions and recommendations were formed based on the study of the existing requirements and on the analysis of the data gathered in the use experience study.

5. Establish the cost implications of the recommendations

   Each recommendation was studied to determine the implications of its implementation on the cost of construction. Some consideration was given to the on-going maintenance costs of various recommendations although it was beyond the scope of this study to develop this.

EXISTING REQUIREMENTS

BACKGROUND

In the study of the requirements for life safety in high commercial buildings existing requirements were studied in terms of:

- the fire experience record
- their frequency of use in the market
- the user experience

It is perhaps relevant to remind ourselves why the extra requirements for high buildings were developed, and to state their objectives in order to establish a standard against which we can develop conclusions as to their effectiveness.

The basis for establishing extra requirements for high buildings is noted in the Supplement to the National Building Code of Canada as follows:

> "Experience has shown that the time required for the complete evacuation of a high building can exceed that which is considered necessary for the safe egress of all occupants. Studies of the 'chimney effect' and observations of smoke movement in fires have shown that present measures for containing a fire on a lower storey will not usually prevent the movement of smoke through the elevator, stair or other vertical shaft to the upper storeys of a high building.
>
> The objectives of the measures for fire safety in high buildings are:
>
> a) to provide for the safety of the occupants of a building, either by maintaining the tenability of the occupied floor spaces during the period of a fire emergency or by making it possible for occupants to move to a place of safety;
>
> b) to maintain tenable conditions in exit stairs leading from floor spaces to the outdoors in which occupants may remain; and

c) to maintain tenable conditions in elevators that can be used to transport fire fighters and their equipment from the street floor to the floor immediately below the fire floor.

The requirements that applied in the Code prior to the implementation of the requirements of Subsection 3.2.6. covering widths of exits and travel distances to exits made it possible for occupants of a floor on which a fire occurs to leave that floor. However, consideration had not been given to the time required to leave the building once the occupants were in the exit system.

The objectives of the measures are to maintain certain spaces substantially smoke-free for a significant period of time during a fire emergency, and hence some criterion of tenability is called for. It has been agreed that the criterion for long term tenability should be that a space shall not include more than 1 percent by volume of the contaminated atmosphere from the fire region. The criterion of tenability is based on considerations of visibility and carbon monoxide concentration".

The earliest of codes have always addressed flammability of construction in buildings, the control of sources of ignition and, to some extent, the actions of people with regard to the starting of fires. With the gradual development of more comprehensive building and fire prevention codes over the years, however, more emphasis has been placed on construction practice as a fire deterrent.

Compartmentation and spatial separation to reduce potentials for fire spread were introduced, as well as the protection or elimination of ignition sources. Until very recently, less emphasis was placed on the human factor. Life safety was based on requirements for exits and alarm systems to provide for evacuation.

Recently, the value of detection and automatic extinguishing systems has been recognized in codes. Most particularly,

automatic sprinklers have been recognized as abating the hazard of large fires and have been permitted to serve as a substitute for some of the compartmentation or subdivision of buildings otherwise required. Now the idea of automatic sprinkler systems designed primarily for life safety rather than full control of a fire is being developed.

Some critics of present codes consider that there has been too much influence from the insurance industry's traditional property protection with the result that there is too much emphasis on reducing fire spread in buildings to save property damage and that these codes should be rewritten for life safety purposes as well.

This is an active controversy among code writers and their critics. The long assumed notion that control of fire spread was synonymous with life protection was dispelled with recent realization that control of fire spread did not necessarily mean control of the gases produced by fires.

This realization came about as a result of noteworthy fires that began to occur in the 1960's in post-war construction, notably in large centrally air conditioned buildings. These included "high-rise" buildings, which involves difficulties of ventilation and access.

The high-rise building fire problem began to reveal itself as a world-wide concern during the 1960's with the experience of serious fires in the increasing numbers of tall curtain wall buildings. Spectacular fires attracted the attention of both the fire protection community and the public. The key fact that became evident was that the modern tall building was structurally fire resistive, but smoke and gases often spread through the structure endangering lives and making fire fighting difficult. Added to this was the fact that traditional emergency exit concepts did not work in such situations. Fire fighters were faced with substantial fires in large floor areas of centrally air conditioned buildings and difficult logistical problems in getting to high fires.

Pioneering work in developing requirements recognizing the special life safety problems in high-rise buildings was carried out in Canada by the National Research Council and

BACKGROUND

the 1970 National Building Code introduced additional requirements for high buildings pertaining to improved detection, alarm, and control and to improved exiting including voice communication and elevator requirements.

Mention was also made at that time of the voluntary use of design guidelines for smoke control.

In 1973 the National Building Code introduced major revisions to these additional requirements by mandating the requirements for smoke control.

In 1975 the Ontario Building Code was introduced including the additional requirements for high buildings. The Ontario Building Code modified the model N.B.C. requirements in two ways:

- the references to specific measures for smoke control as described in A.C.N.B.C. booklet "Measures for Fire Safety in High Buildings" were deleted and the performance requirements described in the N.B.C. were left.

- the requirements for smoke control in high apartment buildings were deemed to be met by the fire resistive compartmentation of the construction of this type of building.

The intent of modifying the Ontario Building Code to provide performance criteria only for smoke control is sound and could have led to measures not available in the examples (Measures 'A' to 'N') of the A.C.N.B.C. booklet "Measures for Fire Safety in High Buildings".

General practice in Ontario has been to design and construct smoke control measures as outlined in the A.C.N.B.C. booklet. Because of this, this study will deal primarily with a review of the smoke control measures 'A' to 'N'.

FIRE EXPERIENCE RECORD

As it indicates, fire experience is the statistical record of fire and its implications in the occupancies under study.

The statistical information regarding fire experience is steadily improving, but any long term picture providing useful data is not readily available.

The statistical data appendixed to this study is representative of the type of data now available from a variety of sources, unfortunately it has only been developed over a short term period. Rather than a criticism this is, in all probability, the reality of developing separate statistics on a relatively recent phenomenom "the high-rise building".

The samplings taken from the Ontario Fire Marshal indicate that over the years 1976 to 1980 there were no deaths attributable to fire in high office and mercantile occupancies; and that there were two deaths attributable to fire in high hotel occupancies in the same period.

A recent sampling survey of office buildings across North America, undertaken by the Building Owners and Managers Association, indicates there were no deaths to occupants attributable to fire in the past year.

An informal survey undertaken by ourselves during the interview series with officials across Canada indicates similar results to the above surveys.

It should be noted that the fire experience record includes high rise buildings that pre-date the implementation of the requirements for high buildings in Subsection 3.2.6. of the Code.

It should further be noted that we were unable to find an example of any consequential fire in a high building which incorporates the requirements in Subsection 3.2.6. In saying this we have kept in mind that buildings containing these measures are relatively new in that they were not included in the National Building Code until 1973 and provincially, in Ontario, in 1975.

FIRE EXPERIENCE RECORD

Statistically high rise buildings within the scope of this study have an enviable life safety record. We can only speculate as to the reasons for this, however, the following appear to have a major impact:

- the large actively awake population of the office building results in the early discovery of fire and thus the initiation of procedures to deal with it. (This is borne out by the B.O.M.A. survey which indicates that 70% of all fires were detected by individuals and not the building detection systems.)

- compliance of the building stock with the non-combustible compartmentation requirements of our building codes to prevent the spread of fire.

FREQUENCY OF USE

The following summaries of surveys we conducted, serve to indicate the state-of-the-art in Canada in terms of both the measures being utilized on a voluntary basis in the market and the extent of mandating of sprinkler requirements.

The survey of voluntary use of the measures is a summation of both formal and informal surveys that have been carried out by others across Canada. In reading this summary, it should be noted that:

- the survey indicates the relatively small number of buildings that incorporate the measures

- the buildings surveyed in Winnipeg were constructed shortly after the smoke control requirements were implemented whereas buildings in Toronto and Alberta were designed and constructed a few years later

The summary of jurisdictions in Canada mandating sprinkler requirements was based on the results of a questionnaire forwarded to the provincial agency responsible for legislating codes and standards in the Province.

SURVEY OF SMOKE CONTROL SYSTEMS

Survey of smoke control systems installed in high commercial buildings including hotels in major urban centres across Canada.

City	% coverage	Projects Investigated	Measures Employed
Winnipeg (survey conducted by Fire & Bldg. Dept.)	100	7 office buildings 2 hotels	A-3 bldgs F-3 bldgs D-1 bldg A-1 bldg G-1 bldg
Metropolitan Toronto (survey conducted by Rolf Jensen & Assoc for N.R.C.)	90 - 100	7 office buildings 2 hotels	A-7 bldgs G-1 bldg K-1 bldg
Calgary/ Edmonton (informal survey conducted by Bldg. & Fire Depts.)	80 - 90% of all high office and hotels buildings employ Measure 'A'		
Vancouver/ Montreal	It is mandatory to employ Measure 'A' in all high buildings		

SPRINKLER REQUIREMENT SURVEY

Province	Extent of Mandatory Sprinkler Requirements	Extent within Province
Newfoundland/ Labrador	As per N.B.C.	Entire Province
Prince Edward Island	As per N.B.C.	Entire Province
Nova Scotia	All building 3 storeys or higher	Entire Province
New Brunswick	As per N.B.C.	Entire Province
Quebec	As per N.B.C. except in Montreal all buildings within 3.2.6 are sprinklered	Special Requirements - Montreal
Manitoba	As per provincial code based on N.B.C. (mandatory sprinklering presently under consideration)	Entire Province
Saskatchewan	As per N.B.C. plus all hotels over 5 storeys in height	Entire Province
Alberta	As per provincial code based on N.B.C. (mandatory sprinklering presently under consideration)	Entire Province
British Columbia	As per N.B.C. except in Vancouver all buildings within 3.2.6 are sprinklered	Special Requirements - Vancouver

USE AND APPLICATION

This section describes the fourteen smoke control measures outlined in A.C.N.B.C. booklet "Measures for Fire Safety in High Buildings 1980", including comments regarding their application and use experience.

The fourteen measures are described herein as they occur in the A.C.N.B.C. booklet as Measures 'A' to 'N' inclusive.

With the description of each measure, we are including comments regarding their application and the user experience.

It is worthwhile at this time to put into context the importance of the application and experience of the measures with regard to our conclusions and recommendations.

One of the difficulties in determining any conclusions about the cost benefit or cost effectiveness of the measures is the basis for evaluating them.

We determined early in the study that criteria must be developed by which the objectives and reliability and application of the smoke control measures could be weighed.

Conclusions regarding the study of these measures could be made by evaluating the performance in the field against the criteria.

To do this it is necessary to understand that various user groups are involved with the use of the smoke control measure through its development stages:

- Design and Approval
- Installation
- Commissioning
- Maintenance
- Use

USE AND APPLICATION

To establish the reliability of the use and application, interviews were held with various user groups involved in the various stages. The comments regarding their use and application are attached to the following smoke control measures, and represent our interpretation of the results of the interviews and analysis of the volumes of reports and studies available on the topic.

It should further be noted, that the use of any one of the following measures, either by itself or in combination with the others, satisfies the performance requirements for smoke control in high buildings as defined in the building code.

The criteria against which each measure was studied were broken into two main headings:

- criteria relating to the objectives of the smoke control measure to limit the danger to occupants

- criteria relating to the reliability of the smoke control measure to achieve the designed goal taking into account a number of concerns

The objective criteria are:

- Limit the size of the fire:

  Does the measure contribute actively to the suppression of the source of the smoke to limit its developments.

- Detection/Alarm:

  The quality of the detection/alarm capability inherent in the measure to effect a rapid notification of an emergency.

- Control Movement of Smoke:

  To determine what specific areas the measure is limiting smoke movement to and thus what areas are to remain smoke-free.

USE AND APPLICATION

The reliability criteria are:

- The Dependence of Mechanical Reliance:

  To determine the amount of reliance upon a mechanical/electrical power.

- The Complexity of the System Required to Achieve Results:

  To determine the relative number of mechanical/electrical components that must function or interact to achieve results.

- The Complexity of User Knowledge Expected:

  To measure the level of "special knowledge" of a system required by the fire service.

- Dependency on Emergency Power:

  To measure the ability of the smoke control measure, to achieve design results in the event of a power failure.

- Redundancy:

  To measure the inherent capability of the smoke control measure to achieve contributing life safety features beyond the designed results.

- Design/Installation Experience:

  To determine the extent of the actual use history of the measure.

- Testing/Maintenance Experience:

  To determine the use history with the commissioning of the measure and the maintenance standard of the Ontario Fire Code.

USE AND APPLICATION

- Response of Occupant:

  To assess the measure in terms of the apparent complexity of occupant behavior required.

  Recent studies involving an analysis of occupant behavior indicates that panic may not be what we have historically perceived it to be. It is becoming apparent that people do what they understand to be "the thing to do", and then are in potential trouble when they meet the unexpected (for example clawing at locked doors, searching smoke filled corridors for exit doors). It appears that their reponse is rational except when their expectations are not met. This criteria intends to establish if the response requires special knowledge or expected action which may not be realistic in terms of actual emergency conditions.

- Suitability to Building Occupancy:

  To assess the measure in terms of its application and impact on the type of construction, compartmentation quality, normal use of the building, and management of the building. To determine whether in fact some of the measures are practical at all.

MEASURE 'A' - FULLY SPRINKLERED BUILDING

Description of Measure:

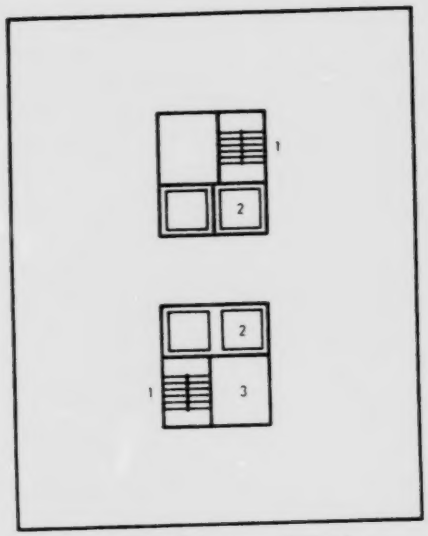


Figure 1 Typical floor plan, Measure A

1. Door to outdoors in each stairshaft held open during a fire emergency (2A(2)).*
   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that storey (2A(3)).
   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2A(3)).
2. Elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2A(5)).
3. Vertical service spaces provided with firestops at the first floor below the lowest exit storey or are vented to outdoors at top (2A(6)).
   Air moving fans are stopped in a system that serves more than 2 storeys (NBC Sentence 3.2.6.2.(6)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Measure A satisfies NBC Sentence 3.2.6.2.(6) for any major occupancy classification.

No limit on height.

All floor areas sprinklered (NBC Sentence 3.2.6.2.(6)).

Limits on flame spread and smoke described in NBC Article 3.2.6.7. are relaxed.

MEASURE 'A' - FULLY SPRINKLERED BUILDING

Application:

Measure 'A' requires the installation of a "supervised" sprinkler system that will transmit a water flow signal and other supervisory signals directly to the fire department, or through an approved independent central station. Therefore, this system functions as a detection and alarm system as well as a fire suppression system. These systems have a proven reliability (refer to Conclusions).

The use of Measure 'A' in Ontario and in Canada for smoke control in high buildings is predicted on the following:

- Certain urban centres in Canada have mandated the installation of sprinklers in high office buildings and hotels.

- Where fire compartments of a building exceed the 1300 m^2 requirements of the O.B.C. or the 1000 m^2 requirements of the N.B.C., it is mandatory to sprinkler those areas effectively making Measure 'A' the logical smoke control measure.

- The building owner for reasons such as life cycle costing, marketing, and other incentives, elects to use the Measure 'A' option.

MEASURE 'A' - FULLY SPRINKLERED BUILDING

Use Criteria for Groups D & E occupancies:

- ☐ Limit the size of the fire:
  - actively suppresses or contains the fire.
- ☐ Detection/Alarm:
  - detection upon actuation of sprinkler.
  - all areas of the building are covered.
- ☐ Control movement of smoke:
  - by limiting the size of the fire the amount of smoke generated is limited
  - reduces temperature of smoke produced
  - does not control the movement of smoke
- ☐ Independence of mechanical reliance:
  - minimal dependence
- ☐ Complexity of system required to achieve results:
  - minimal complexity in that the system consists of piping and pump only.
- ☐ Complexity of fire service knowledge expected:
  - no special knowledge of the system is required.
  - there is a long use history and thus familiarity with the system.
- ☐ Dependency on emergency power:
  - up to 275' the system can be controlled from the siamese connection outside of the building.

MEASURE 'A' - FULLY SPRINKLERED BUILDING

Use Criteria for Groups D & E occupancies:

- Redundancy:
  - measure reduces temperatures but structural protection is same as other measures.
  - simultaneous suppression, detection and alarm function.

- Design/Installation experience:
  - a long history of use and experience.

- Testing/Maintenance experience:
  - a reliable record of commissioning.
  - because the long history of use and because it is a relative simple system maintenance and testing operations are well known, simple, and effective.

- Response of occupant:
  - occupants of the fire area are to leave the building by the stairwells - all other occupants will remain where they are.

- Suitability to building occupancy:
  - simple to install in the suspended ceiling space of open floor areas.
  - readily adaptable to the constant changes in planning including initial tenant installations without unintentionally affecting the designed result.

MEASURE 'A' - FULLY SPRINKLERED BUILDING

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - actively suppresses or contains the fire.

- Detection/Alarm:
  - detection upon actuation of sprinkler.
  - all areas of the building are covered.

- Control movement of smoke:
  - by limiting the size of the fire the amount of smoke generated is limited
  - reduces temperature of smoke produced
  - does not control the movement of smoke

- Dependence of mechanical reliance:
  - minimal dependence

- Complexity of system required to achieve results:
  - minimal complexity in that the system consists of piping and pump only.

- Complexity of user knowledge expected:
  - no special knowledge of the system is required.
  - there is a long use history and thus familiarity with the system.

- Dependency on emergency power:
  - up to 275' the system can be controlled from the siamese connection outside of the building.

MEASURE 'A' - FULLY SPRINKLERED BUILDING

Use Criteria for Group C (hotel) occupancies:

- Redundancy:
  - measure reduces temperatures but structural protection is same as other measures.
  - simultaneous suppression, detection and alarm function.

- Design/Installation experience:
  - a long history of use and experience.

- Testing/Maintenance experience:
  - a reliable record of commissioning.
  - because the long history of use and because it is a relative simple system maintenance and testing operations are well known, simple, and effective.

- Response of occupant:
  - occupants of the fire area are to leave the building by the stairwells - all other occupants will remain where they are.

- Suitability to building occupancy:
  - not as simple to install because of the minimal amount of suspended ceiling space and the number of small spaces such as washrooms and closets (this usually requires a larger number of heads for the same floor area of an open office plan).

MEASURE 'B' - OPEN CORRIDOR ACCESS TO STAIRS AND ELEVATORS (including restrictions on movement of smoke from floor to floor)

Description of Measure:

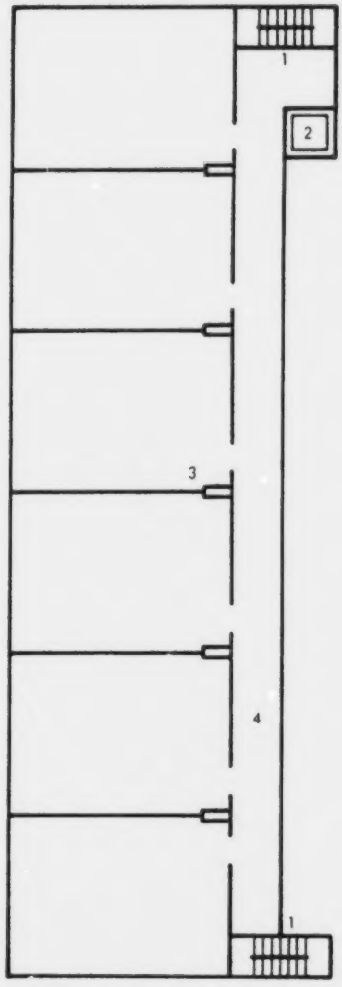


Figure 2 Typical floor plan, Measure B

1. Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that storey (2B(3)).*

   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2B(3)).

2. Elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2B(4)).

3. Vertical service spaces provided with firestops at the first floor below the lowest exit storey and at intervals not exceeding 5 storeys or are vented to outdoors at top (2B(5)).

4. Open corridor or balcony providing access to stairs and fire fighters' elevator (2B(2)).

   Elevator shaft and stairshaft unheated.

   Air moving fans are stopped in a system that serves more than 2 storeys (2B(7)).

   Certain dampers close in air handling ducts during a fire emergency (2B(8)).

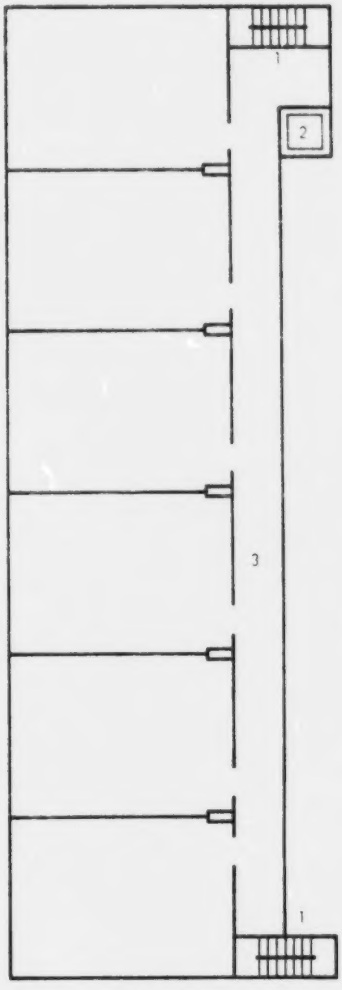
*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Measure B satisfies NBC Sentences 3.2.6.2.(2), (3) and (4) for any major occupancy classification.

No limit on height.

MEASURE 'C' - OPEN CORRIDOR ACCESS TO STAIRS AND ELEVATORS (with no additional restrictions on movement of smoke from floor to floor

Description of Measure:



1. Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that storey (2C(3))*

   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2C(3)).

2. Elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2C(4)).

3. Open corridor or balcony providing access to stairs and fire fighters' elevator (2C(2)).

   Elevator shaft and stairshaft unheated.

   Air moving fans are stopped in a system that serves more than 2 storeys (2C(5)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 3 Typical floor plan, Measure C

Measure C satisfies NBC Sentence 3.2.6.2.(7) for Groups A, C, D, E or F, major occupancy classification.

Limit on population (NBC Sentence 3.2.6.2.(7)).

Limited to buildings not more than 75 m high (NBC Sentence 3.2.6.2.(7)).

MEASURES 'B' AND 'C'

Application:

Measures 'B' and 'C' separate the vertical stairways and elevator shafts from the remainder of the building with the use of exterior walkways or permanently vented corridors. This feature removes the possibility that smoke will travel through the shafts to the upper storeys. The exterior walkways at the same time provide vented smoke-free areas. It should be noted that the use of these measures does not exclude the use of elevators within heated floor areas, provided they are protected against the entry of smoke. These measures afford protection from smoke for the occupants by the inherent configuration and design of the building.

MEASURES 'B' AND 'C'

Use Criteria for Groups D & E occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - areas of the building covered are those under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - egress routes from all rooms and the fire area are protected from smoke

- Dependence of mechanical reliance:
  - these measures are independent of mechanical reliance and inherent in this is the fact that the measure is always activated and does not rely on power actuation

- Complexity of system required to achieve results:
  - minimal complexity in that the measures require no mechanical parts

- Complexity of user knowledge expected:
  - no special knowledge is required as the system is continually activated

MEASURES 'B' AND 'C'

Use Criteria for Groups D & E occupancies:

- Dependency on emergency power:
  - the measures work independently of the electrical power supply of the building
- Redundancy:
  - these measures are designed specifically as smoke control measures and have no redundant attributes
- Design/Installation experience:
  - there was no experience found with these measures
- Testing/Maintenance experience:
  - there is no experience with these measures
- Response of occupant:
  - occupants of the fire area are to leave the building - all other occupants would leave as it was necessary
- Suitability to building occupancy:
  - because of the historical planning of buildings in the inclement climatic criteria of Ontario these measures are not applicable

MEASURES 'B' AND 'C'

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - areas of the building covered are those under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - egress routes from all rooms and the fire area are protected from smoke

- Dependence of mechanical reliance:
  - these measures are independent of mechanical reliance and inherent in this is the fact that the measure is always activated and does not rely on power actuation

- Complexity of system required to achieve results:
  - minimal complexity in that the measures require no mechanical parts

- Complexity of user knowledge expected:
  - no special knowledge is required as the system is continually activated

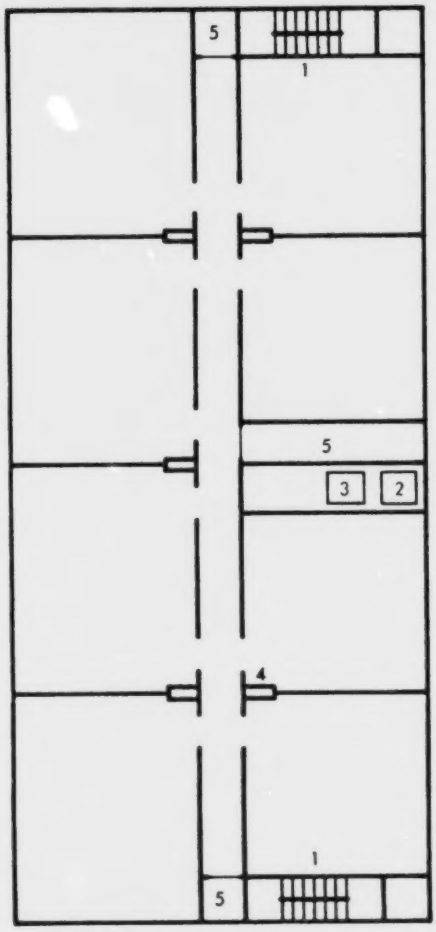
MEASURES 'B' AND 'C'

Use Criteria for Group C (hotel) occupancies:

- Dependency on emergency power:
  - the measures work independently of the electrical power supply of the building
- Redundancy:
  - these measures are designed specifically as smoke control measures and have no redundant attributes
- Design/Installation experience:
  - there was no experience found with these measures
- Testing/Maintenance experience:
  - there is no experience with these measures
- Response of occupant:
  - occupants of the fire area are to leave the building - all other occupants would leave as it was necessary
- Suitability to building occupancy:
  - because of the historical planning of buildings in the inclement climatic criteria of Ontario these measures are not applicable

MEASURE 'D' - PROTECTED VESTIBULE ACCESS TO STAIRS & ELEVATORS (including restrictions on movement of smoke from floor to floor)

Description of Measure:



1. Door to outdoors in each stairshaft held open during a fire emergency (2D(7)).*

   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that level (2D(8)).

   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2D(8)).

2. Elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2D(13)).

3. Fire fighters' elevator shaft provided with vent to outdoors at top and bottom during a fire emergency if the vestibule protection is by pressurization (2D(9)).

4. Vertical service spaces provided with firestops at the first floor below the lowest exit storey and at intervals not exceeding 5 storeys or are vented to outdoors at top (2D(12)).

5. Vestibule vented to outdoors during a fire emergency or pressurized (2D(5)).

   Vents to vestibules openable from central control facility if building is over 36 m high (2D(6)).

   Air moving fans are stopped in a system that serves more than 2 storeys (2D(15)).

   Certain dampers close in air handling ducts during a fire emergency (2D(16)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 4 Typical floor plan, Measure D

Measure D satisfies NBC Sentences 3.2.6.2.(2), (3) and (4) for any major occupancy classification.

No limit on height.

MEASURE 'E' - PROTECTED VESTIBULE ACCESS TO STAIRS & ELEVATORS (with no additional restrictions on movement of smoke from floor to floor)

Description of Measure:

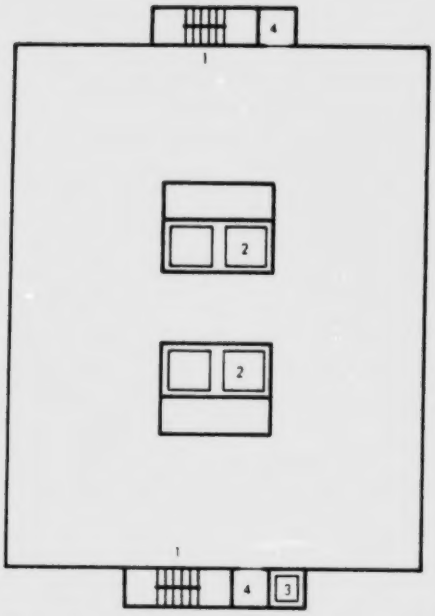


Figure 5 Typical floor plan, Measure E

1. Door to outdoors in each stairshaft held open during a fire emergency (2E(6)).*

   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that level (2E(7)).

   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2E(7)).

2. Elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2E(11)).

   No special protection against smoke for elevator shafts or vertical service spaces other than fire fighters' elevator.

3. Fire fighters' elevator shaft provided with vent to outdoors at top and bottom during a fire emergency (2E(8)).

4. Vestibule vented to outdoors during a fire emergency or pressurized (2E(4)).

   Vents to vestibules openable from central control facility if building is over 36 m high (2E(5)).

   Air moving fans are stopped in a system that serves more than 2 storeys (2E(12)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Measure E satisfies NBC Sentence 3.2.6.2.(7) for Groups A, C, D, E or F, major occupancy classification.

Limit on population (NBC Sentence 3.2.6.2.(7)).

Limited to buildings not more than 75 m high (NBC Sentence 3.2.6.2.(7)).

MEASURES 'D' AND 'E'

Application:

Measures 'D' and 'E' prevent the movement of smoke through stair and elevator shafts by the provision of vestibules that are either vented to the outdoors or have outdoor air injected into them. Stair shafts are further protected by opening a door to the outdoors at the bottom of the shaft. Where vestibules are protected by the injection of outdoor air, the elevator shaft is provided with a large opening to the outdoors at the bottom and a smaller opening at the top.

MEASURES 'D' AND 'E'

Use Criteria for Groups D & E occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - areas of the building covered are those under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - the vertical stairways and elevators are protected from the entry of smoke

- Dependence of mechanical reliance:
  - the pressurization of the vestibule is dependent on the proper functioning of mechanical controls
  - the venting of vestibules to the outside is minimally dependent on mechanical controls

- Complexity of system required to achieve results:
  - the pressurization of vestibules is moderately complex
  - the venting of vestibules to the outside is relatively simple and is even more so if designed for manual operation

MEASURES 'D' AND 'E'

Use Criteria for Groups D & E occupancies:

- Complexity of user knowledge expected:
  - the pressurization of vestibules although not complex for a system designer can, depending on the design, require special knowledge on the part of the user
  - the manual venting of vestibules to the outside requires no special knowledge

- Dependency on emergency power:
  - the operation of a pressurization system or automated venting system is entirely dependent on the continued supply of power

- Redundancy:
  - these measures are designed specifically as smoke control measures and have no redundant attributes

- Design/Installation experience:
  - there was no experience found with these measures

- Testing/Maintenance experience:
  - there is no experience with these measures

- Response of occupant:
  - occupants of the fire area are to leave the building - all other occupants would leave as it was necessary

MEASURES 'D' AND 'E'

Use Criteria for Groups D & E occupancies:

- Suitability to building occupancy:
  - these measures have a dramatic impact on the rentable area of a building and adversely affect the planning efficiency of a building
  - the loss of potential rentable area and the impact in the long term planning flexibility make it a less desirable smoke control measure alternative

MEASURES 'D' AND 'E'

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - areas of the building covered are those under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - the vertical stairways and elevators are protected from the entry of smoke

- Dependence of mechanical reliance:
  - the pressurization of the vestibule is dependent on the proper functioning of mechanical controls;
  - the venting of vestibules to the outside is minimally dependent on mechanical controls

- Complexity of system required to achieve results:
  - the pressurization of vestibules is moderately complex
  - the venting of vestibules to the outside is relatively simple and is even more so if designed for manual operation

MEASURES 'D' AND 'E'

Use Criteria for Group C (hotel) occupancies:

- Complexity of user knowledge expected:
  - the pressurization of vestibules although not complex for a system designer can, depending on the design, require special knowledge on the part of the user
  - the manual venting of vestibules to the outside requires no special knowledge

- Dependency on emergency power:
  - the operation of a pressurization system or automated venting system is entirely dependent on the continued supply of power

- Redundancy:
  - these measures are designed specifically as smoke control measures and have no redundant attributes

- Design/Installation experience:
  - only a few installations of these measures were found

- Testing/Maintenance experience:
  - an extensive test of an installation proved that the system achieved the design results intended
  - the above test was a special and to date there is little use history to accurately comment on the commissioning of a vestibule measure for smoke control under normal means

MEASURES 'D' AND 'E'

Use Criteria for Group C (hotel) occupancies:

- Response of occupant:
  - occupants of the fire area are to leave the building - all other occupants would leave as it was necessary

- Suitability to building occupancy:
  - these measures are suited to the planning criteria of this occupancy and offer a viable option when considering the choice of a smoke control measure

MEASURE 'F' - PRESSURIZED STAIR AND ELEVATOR SHAFTS (including restrictions on movement of smoke from floor to floor)

Description of Measure:

Figure 6 Typical floor plan, Measure F

1. Door to outdoors in each stairshaft held open during a fire emergency (2F(2)).*
   Stairshaft pressurized during a fire emergency (2F(2)).
   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that level (2F(3)).
   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2F(3)).
2. Fire fighters' elevator shaft pressurized during a fire emergency (2F(4)).
3. Elevator shafts other than fire fighters' elevator vented to outdoors at top (2F(8)).
4. Vertical service spaces provided with firestops at the first floor below the lowest exit storey and at intervals not exceeding 5 storeys or are vented to outdoors at top (2F(7)).
   Air moving fans are stopped in a system that serves more than 2 storeys during a fire emergency (2F(11)).
   Certain dampers in air-handling ducts close during a fire emergency (2F(12)).

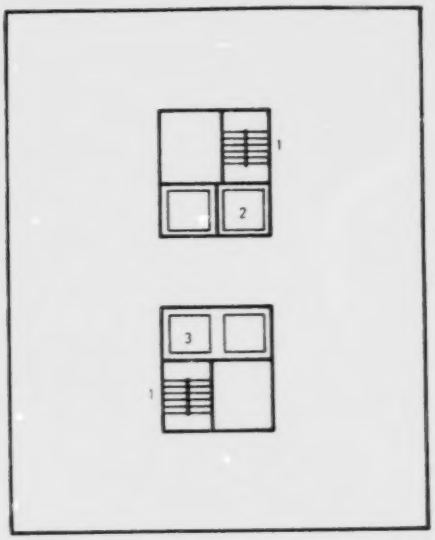
*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Measure F satisfies NBC Sentences 3.2.6.2.(2), (3) and (4) for any major occupancy classification.

No limit on height.

MEASURE 'G' - PRESSURIZED STAIR AND ELEVATOR SHAFTS (with no additional restrictions on movement of smoke from floor to floor)

Description of Measure:



1. Door to outdoors in each stairshaft held open during a fire emergency (2G(2)).*
   Stairshaft pressurized during a fire emergency (2G(2)).
   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that level (2G(3)).
   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2G(3)).
2. Fire fighters' elevator shaft pressurized during a fire emergency (2G(4)).
3. No special protection against smoke for elevator shafts or vertical service spaces other than fire fighters' elevator.
   Air moving fans are stopped in a system that serves more than 2 storeys during a fire emergency (2G(7)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 7 Typical floor plan, Measure G

Measure G satisfies NBC Sentence 3.2.6.2.(7) for Groups A, C, D, E or F, major occupancy classification.

Limit on population (NBC Sentence 3.2.6.2.(7)).

Limited to buildings not more than 75 m high (NBC Sentence 3.2.6.2.(7)).

MEASURES 'F' AND 'G'

Application:

Measures 'F' and 'G' prevent the movement of smoke through stair and elevator shafts by injecting sufficient outside air to provide pressures in stair shafts and in one or more protected elevator shafts that will be at least equal to the outdoor air at ground level.

MEASURES 'F' AND 'G'

Use Criteria for Groups D & E occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - areas of the building covered are those under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - the vertical stairwells and elevator shafts are protected from smoke

- Dependence of mechanical reliance:
  - these measures are entirely dependent on mechanical controls

- Complexity of system required to achieve results:
  - the apparent simplicity of these measures is defeated by the necessity to provide an excellent air distribution system to modulate the supply to overcome potential problems of pressure differentials making the opening of doors difficult while losing pressurization on other floors where fire fighting and rescue operations necessitate open doors

MEASURES 'F' AND 'G'

Use Criteria for Groups D & E occupancies:

- Complexity of user knowledge expected:
  - the system can require special knowledge on the part of the user especially in very high buildings where air distribution may require the introduction of further mechanical components

- Dependency on emergency power:
  - these measures are entirely dependent on the continued supply of electrical power

- Redundancy:
  - these measures are specifically designed as smoke control measures and have no redundant attributes

- Design/Installation experience:
  - there is minimal experience with the installation of these measures

- Testing/Maintenance experience:
  - the minimal experience there is with these measures is very mixed. Reports from some municipal authorities show repeated failure and show a loss of pressurization under simulated conditions of multi level door opening
  - testing has shown that a real concern exists about the ability of even a healthy being to open stairwell doors on high storeys

MEASURES 'F' AND 'G'

Use Criteria for Groups D & E occupancies:

- Response of occupant:
  - occupants of the fire area are to leave the building - all other occupants would leave as it became necessary

- Suitability to building occupancy:
  - these measures are readily adaptable to the building occupancy
  - there is some concern amongst designers of these measures that buildings over 250' in height cannot be pressurized in the stairwells and shafts without the introduction of complexities that could economically outweigh any benefits

MEASURES 'F' AND 'G'

Use Criteria for Group C (hotel) occupancies:

- Complexity of user knowledge expected:
  - the system can require special knowledge on the part of the user especially in very high buildings where air distribution may require the introduction of further mechanical components

- Dependency on emergency power:
  - these measures are entirely dependent on the continued supply of electrical power

- Redundancy:
  - these measures are specifically designed as smoke control measures and have no redundant attributes

- Design/Installation experience:
  - there is minimal experience with the installation of these measures

- Testing/Maintenance experience:
  - the minimal experience there is with these measures is very mixed. Reports from some municipal authorities show repeated failure and show a loss of pressurization under simulated conditions of multi level door opening
  - testing has shown that a real concern exists about the ability of even a healthy being to open stairwell doors on high storeys

MEASURES 'F' AND 'G'

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - areas of the building covered are those under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - the vertical stairwells and elevator shafts are protected from smoke

- Dependence of mechanical reliance:
  - these measures are entirely dependent on mechanical controls

- Complexity of system required to achieve results:
  - the apparent simplicity of these measures is defeated by the necessity to provide an excellent air distribution system to modulate the supply to overcome potential problems of pressure differentials making the opening of doors difficult while losing pressurization on other floors where fire fighting and rescue operations necessitate open doors

MEASURES 'F' AND 'G'

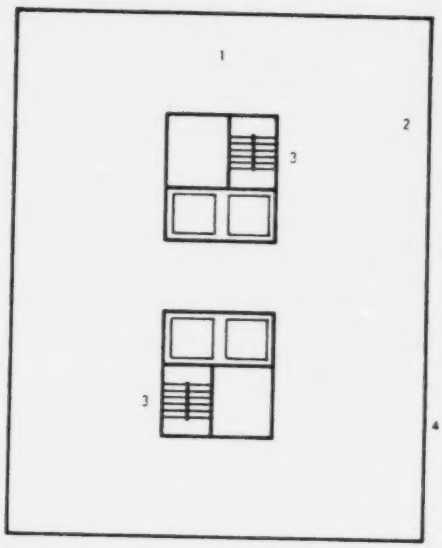
Use Criteria for Group C (hotel) occupancies:

- Response of occupant:
  - occupants of the fire area are to leave the building - all other occupants would leave as it became necessary

- Suitability to building occupancy:
  - these measures are readily adaptable to the building occupancy
  - there is some concern amongst designers of these measures that buildings over 250' in height cannot be pressurized in the stairwells and shafts without the introduction of complexities that could economically outweigh any benefits

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Description of Measure:



1. All floor areas pressurized (2H(2)).*
   Provision for modulating air supply for building pressurization during warm weather (2H(4)).
2. Fire floor provided with means of venting to outdoors by smokeshaft or windows (2H(7)).
3. A proportion of air for building pressurization directed into stairshafts (2H(2)).
   Doors to outdoors in stairshafts not held open during a fire emergency (2H(5)).
4. Except as required for venting, all openings in perimeter walls and roof are kept closed during a fire emergency (2H(5)).
   Except as required for pressurization, air moving fans are stopped in a system that serves more than 2 storeys during a fire emergency (2H(4)).
   Certain dampers in air handling ducts are closed during a fire emergency (2H(6)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 8 Typical floor plan, Measure H

Measure H satisfies NBC Sentences 3.2.6.2.(2), (3) and (4) for any major occupancy classification.

No limit on height.

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Application:

In Measure 'H' the air pressure in the total building is increased so that it is at least equal to the outdoor pressure at grade level. The air pressure on the fire floor is reduced by stopping the supply air, and in the rest of the building it is increased by chutting off the exhaust air.

A certain proportion of air must be injected into the vertical shafts to reduce the possibility that a door opened at the bottom of a shaft, especially in warm weather, will not cause sufficient loss in the air pressure in the shaft to cause smoke to flow into the shaft from other floor areas.

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Use Criteria for Groups D & E occupancies:

- ☐ Limit the size of the fire:
  - this measure does not actively suppress or contain the fire

- ☐ Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
  - it is critical to the effective operation of this measure that the correct fire floor is detected and designated

- ☐ Control movement of smoke:
  - all areas of the building other than the fire floor including vertical shafts are protected from smoke

- ☐ Dependence of mechanical reliance:
  - this measure is entirely dependent on mechanical control

- ☐ Complexity of system required to achieve results:
  - the measure utilizes the normal air distribution system with extra controls for emergency use
  - variations of the measure have varying degrees of complexity

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Use Criteria for Groups D & E occupancies:

- Complexity of user knowledge expected:
  - this measure requires special knowledge and is susceptible to the difficulties expressed in our interviews:
    - the education and re-education of persons responsible for the control of the system in an emergency
    - the dependency on the accurate identification of the fire floor. (The consequences of an error in determining the fire floor are severe as smoke will be spread rapidly by this measure to other floors.)
- Dependency on emergency power:
  - this measure is entirely dependent on the continued supply of electrical power
- Redundancy:
  - this measure is specifically designed as a smoke control measure and has no redundant attributes
- Design/Installation experience:
  - a number of installations of this measure can be found, and a number of variations are recently appearing

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Use Criteria for Groups D & E occupancies:

- Testing/Maintenance experience:
  - the following concerns with this measure were expressed by authorities creating doubts about its effectiveness and reliability:
    - failure to satisfy the approving authorities of the proper commissioning of the system
    - a repeated history of failure of testing requiring re-testing and re-testing, and growing suspicion that the system is never quite perfected
    - the necessary maintenance of dampers (an integral component) which, in accordance with practices outlined in the Ontario Fire Code, are on a rotational basis add to the debate of reliability

- Response of occupant:
  - the occupants of the fire floor leave the building, other occupants would leave the building as it became necessary

- Suitability to building occupancy:
  - the measure is readily adaptable to the normal planning and construction of these occupancies
  - unintentional but potentially devastating alterations to the system through constant tenant changes and improvements have been recorded
  - one aspect of this measure that has not been studied is the impact of modern energy management practices
  - the potential for human error in this measure is very high in an emergency situation and although it is seemingly simple in its application it requires an effective and accurate response

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - this measure does not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
  - it is critical to the effective operation of this measure that the correct fire floor is detected and designated

- Control movement of smoke:
  - all areas of the building other than the fire floor including vertical shafts are protected from smoke

- Dependence of mechanical reliance:
  - this measure is entirely dependent on mechanical control

- Complexity of system required to achieve results:
  - it is difficult to implement this measure without great complexity owing to the high degree of compartmentation of building and the unitization of the mechanical system

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Use Criteria for Group C (hotel) occupancies:

- Complexity of user knowledge expected:
  - this measure requires special knowledge and is susceptible to the difficulties expressed in our interviews:
    - the education and re-education of persons responsible for the control of the system in an emergency
    - the dependency on the accurate identification of the fire floor. (The consequences of an error in determining the fire floor are severe as smoke will be spread rapidly by this measure to other floors.)
- Dependency on emergency power:
  - this measure is entirely dependent on the continued supply of electrical power
- Redundancy:
  - this measure is specifically designed as a smoke control measure and has no redundant attributes
- Design/Installation experience:
  - a number of installations of this measure can be found, and a number of variations are recently appearing

MEASURE 'H' - BUILDING FULLY PRESSURIZED

Use Criteria for Group C (hotel) occupancies:

- Testing/Maintenance experience:
  - the following concerns with this measure were expressed by authorities creating doubts about its effectiveness and reliability:
    - failure to satisfy the approving authorities of the proper commissioning of the system
    - a repeated history of failure of testing requiring re-testing and re-testing, and growing suspicion that the system is never quite perfected
    - the necessary maintenance of dampers (an integral component) which, in accordance with practices outlined in the Ontario Fire Code, are on a rotational basis add to the debate of reliability

- Response of occupant:
  - the occupants of the fire floor leave the building, other occupants would leave the building as it became necessary

- Suitability to building occupancy:
  - the measure is not easily adaptable to the high degree of compartmentation of the planning and the utilization of the mechanical system

MEASURE 'I' - PARTIALLY PRESSURIZED BUILDING (including restrictions on movement of smoke from floor to floor outside core)

Description of Measure:

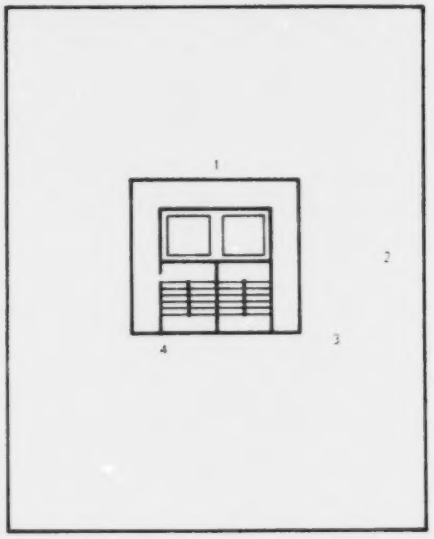


Figure 9 Typical floor plan, Measure I

1. Enclosing wall of core is a fire separation with self closing doors.
   Central core is pressurized during a fire emergency (2I(2)).*
   All openings in perimeter walls and roof of core kept closed during a fire emergency (2I(3)).
2. Fire compartment is vented to outdoors during a fire emergency by smokeshaft or windows (2I(4)).
3. Vertical service spaces outside core provided with firestops at the level of the first floor below the lowest exit storey and at intervals not exceeding 5 storeys or are vented to outdoors at the top (2I(6)).
4. Doors to outdoors in stairshafts not held open during a fire emergency except as required for pressurizing the core (2I(3)).
   Air moving fans are stopped in a system that serves more than 2 storeys in a fire emergency (2I(7)).
   Certain dampers in air handling ducts are closed during a fire emergency (2I(8)).

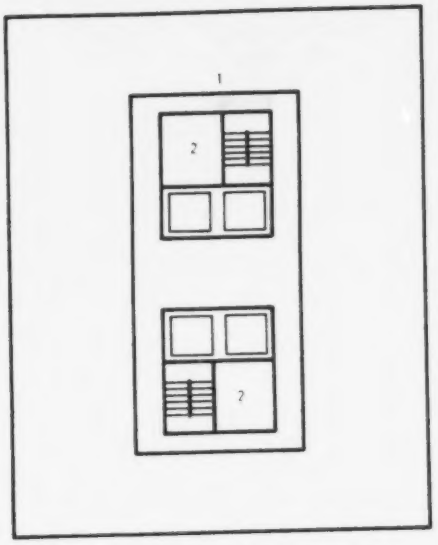
*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Measure I satisfies NBC Sentences 3.2.6.2.(2), (3) and (4) for any major occupancy classification.

No limit on height.

MEASURE 'J' - PARTIALLY PRESSURIZED BUILDING (with no additional restrictions on movement of smoke from floor to floor outside core

Description of Measure:



1. Enclosing wall of core is a fire separation with self closing doors.
   Central core is pressurized during a fire emergency (2J(2)).*
   All openings in perimeter walls and roof of core are kept closed during a fire emergency (2J(3))
2. Doors to outdoors in stairshafts not held open during a fire emergency (2J(3)).
   Air moving fans are stopped in a system that serves more than 2 storeys in a fire emergency (2J(4)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 10 Typical floor plan, Measure J

Measure J satisfies NBC Sentence 3.2.6.2.(7) for Groups A, C, D, E or F, major occupancy classification.

Limit on population (NBC Sentence 3.2.6.2.(7)).

Limited to buildings not more than 75 m high (NBC Sentence 3.2.6.2.(7)).

MEASURES 'I' AND 'J'

Application:

Measures 'I' and 'J' are very similar to Measure 'H', except that they may be applied in buildings with openable fenestration on the exterior walls. The central core includes exit stairs, elevator shafts and public corridors.

MEASURES 'I' AND 'J'

Use Criteria for Groups D & E occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - only areas of the building covered under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - all areas of the core including vertical shafts are protected from smoke
  - concern has been expressed that a fire in the core could contaminate the building very quickly upon actuation of the measure

- Dependence of mechanical reliance:
  - these measures are entirely dependent on mechanical control

- Complexity of system required to achieve results:
  - these measures are relatively complex owing to the large area of building to be pressurized
  - effectiveness of these measures is questionable unless sophisticated in design

- Complexity of user knowledge expected:
  - these measures require special knowledge on the part of the user

MEASURES 'I' AND 'J'

Use Criteria for Groups D & E occupancies:

- Dependency on emergency power:
  - these measures are entirely dependent on the continued supply of electrical power
- Redundancy:
  - these measures are specifically designed as smoke control measures and have no redundant attributes
- Design/Installation experience:
  - no use history of these measures was found
- Testing/Maintenance experience:
  - no use history was found to establish comment but one would anticipate problems similar to those expressed for Measure 'H'
- Response of occupant:
  - occupants of the fire area would leave the building - other occupants would leave as it became necessary
- Suitability to building occupancy:
  - these measures are unsuitable to the configuration of a multi tenancy occupancy that does not have a well defined and separated core

MEASURES 'I' AND 'J'

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - these measures do not actively suppress or contain the fire

- Detection/Alarm:
  - detection/alarm is not an inherent feature of these measures
  - only areas of the building covered under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - all areas of the core including vertical shafts are protected from smoke
  - concern has been expressed that a fire in the core could contaminate the building very quickly upon actuation of the measure

- Dependence of mechanical reliance:
  - these measures are entirely dependent on mechanical control

- Complexity of system required to achieve results:
  - these measures are relatively complex owing to the large area of building to be pressurized
  - effectiveness of these measures is questionable unless sophisticated in design

- Complexity of user knowledge expected:
  - these measures require special knowledge on the part of the user

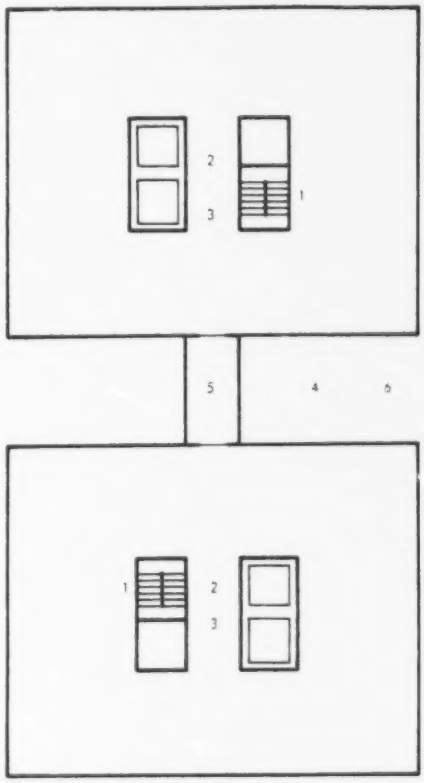
MEASURES 'I' AND 'J'

Use Criteria for Group C (hotel) occupancies:

- Dependency on emergency power:
  - these measures are entirely dependent on the continued supply of electrical power
- Redundancy:
  - these measures are specifically designed as smoke control measures and have no redundant attribures
- Design/Installation experience:
  - use history of these measures are limited
- Testing/Maintenance experience:
  - no comment was available on the testing and maintenance experience
- Response of occupant:
  - occupants of the fire area would leave the building - other occupants would leave as it became necessary
- Suitability to building occupancy:
  - these measures are more adaptable to this occupancy because of the well defined core area

MEASURE 'K' - VERTICALLY DIVIDED BUILDING (with spatial separation or fire separation)

Description of Measure:



1. Door to outdoors in each stairshaft held open during a fire emergency (2K(13)).*
2. One fire fighters' elevator and 1 stairshaft in each smoke control region (2K(4)).
3. If bridges do not occur at each storey, 2 stairshafts are required in each smoke control region (NBC 3.4.2.1.).
4. Building designed as 2 smoke control regions with spatial separation between (2K(2)).
5. Bridge at intervals not exceeding 5 storeys, except that in buildings of Group C major occupancy more than 75 m in height, the bridge is at each storey (2K(3))
   Bridge vented to outdoors or pressurized (2K(11)).
6. Fire separation in storeys below grade to maintain separation between smoke control regions (2K(15)).
   Air moving fans are stopped in a system that serves more than 2 storeys in a fire emergency (2K(14)).

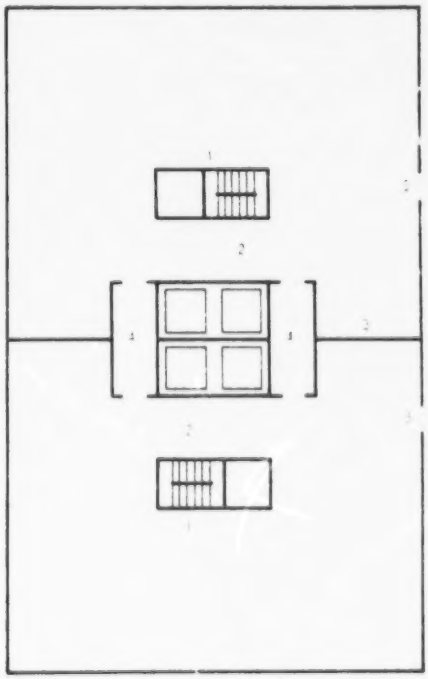
*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 11 Typical floor plan, Measure K

Measure K satisfies NBC Sentence 3.2.6.2.(5) for buildings of Groups A, C, D, E or F, major occupancy classification of any height.

MEASURE 'K' - VERTICALLY DIVIDED BUILDING (with spatial separation or fire separation)

Description of Measure:



1. Door to outdoors in each stairshaft held open during a fire emergency (2K(13)).*
2. One fire fighters' elevator and 1 stairshaft in each smoke control region (2K(4)).

   If vestibules do not occur at each storey, 2 stairshafts are required in each smoke control region (NBC 3.4.2.1.).
3. Building designed as 2 smoke control regions with fire separation between (2K(2))

   Fire separation in storeys below grade to maintain separation between smoke control regions (2K(15)).
4. Vestibule at intervals not exceeding 5 storeys, except that in the case of buildings of Group C major occupancy more than 75 m in height, the vestibule is at each storey (2K(3)).

   Vestibules vented to outdoors or pressurized (2K(11)).
5. Vent to outdoors in each smoke control region on floors below mid height of building (2K(12))

   Air moving fans are stopped in a system that serves more than 2 storeys during a fire emergency (2K(14)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 12 Typical floor plan, Measure K

Measure K satisfies NBC Sentence 3.2.6.2.(5) for buildings of Groups A, C, D, E or F, major occupancy classification of any height.

MEASURE 'K' - VERTICALLY DIVIDED BUILDING

Application:

Measure 'K' divides the building in two by providing either a spatial separation with vented or pressurized bridges between the two "buildings", or a fire separation with pressurized vestibules between the two "buildings". These bridges or vestibules must be provided at intervals not exceeding five floors.

MEASURE 'K' - VERTICALLY DIVIDED BUILDING

Use Criteria for Groups D & E occupancies:

- Limit the size of the fire:
  - this measure does not actively suppress the fire but does act to contain the fire to one part of the building

- Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
  - only areas of the building covered under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - building areas each side of the vertical separation are protected from smoke from the other side

- Dependence of mechanical reliance:
  - the amount of mechanical reliance is similar to that of Measures 'D' and 'E'

- Complexity of system required to achieve results:
  - this measure can vary from being relatively simple in vented vestibules to more complex when pressurized

- Complexity of user knowledge expected:
  - depending on the variation (i.e., vented or pressurized) it can require no special knowledge or some special knowledge

MEASURE 'K' - VERTICALLY DIVIDED BUILDING

Use Criteria for Groups D & E occupancies:

- Dependency on emergency power:
  - pressurized separation is dependent on continued electrical power
- Redundancy:
  - this measure is specifically designed as a smoke control measure and has no redundant attributes
- Design/Installation experience:
  - no use history of this measure was found
- Testing/Maintenance experience:
  - no use history was found to establish comment
- Response of occupant:
  - it is anticipated that the occupant of the fire area will enter the "other" building and that other occupants will also do this as it becomes necessary
  - the user will require special knowledge of his action in this area of refuge concept in that he will be asked to enter the stairwell and re-enter the building on a dedicated floor
- Suitability to building occupancy:
  - this measure is unsuitable to the flexible planning requirements of open office space

MEASURE 'K' - VERTICALLY DIVIDED BUILDING

Use Criteria for Group C (hotel) occupancies:

- Limit the size of the fire:
  - this measure does not actively suppress the fire but does act to contain the fire to one part of the building

- Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
  - only areas of the building covered under the requirements of Subsection 3.2.4.

- Control movement of smoke:
  - building areas each side of the vertical separation are protected from smoke from the other side

- Dependence of mechanical reliance:
  - the amount of mechanical reliance is similar to that of Measures 'D' and 'E'

- Complexity of system required to achieve results:
  - this measure can vary from being relatively simple in vented vestibules to more complex when pressurized

- Complexity of user knowledge expected:
  - depending on the variation (i.e., vented or pressurized) it can require no special knowledge or some special knowledge

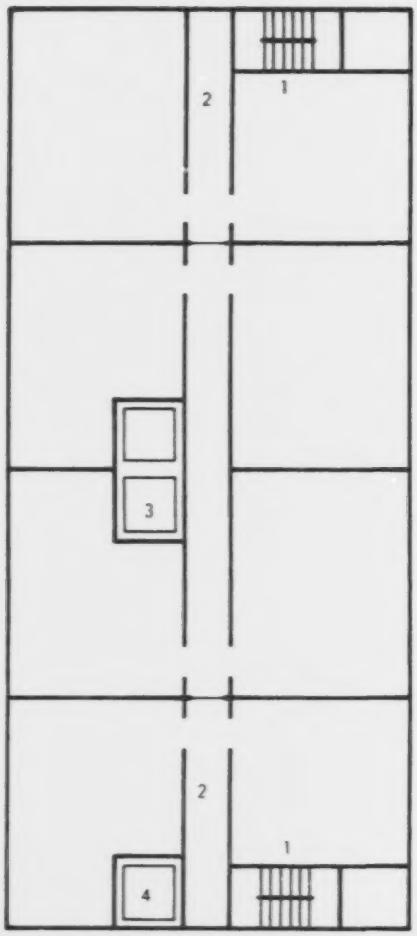
MEASURE 'K' - VERTICALLY DIVIDED BUILDING

Use Criteria for Group C (hotel) occupancies:

- Dependency on emergency power:
  - pressurized separation is dependent on continued electrical power
- Redundancy:
  - this measure is specifically designed as a smoke control measure and has no redundant attributes
- Design/Installation experience:
  - only one installation of this measure was found
- Testing/Maintenance experience:
  - no comment regarding the experience of this measure could be established
- Response of occupant:
  - it is difficult to accept that an occupant, who in this type of building is transient, would ever be educated to accept an area of refuge concept, especially when he has to learn that in a building under 75 m in height he has to travel to another floor and in a building over 75 m he may move to the area of refuge on the same floor
- Suitability to building occupancy:
  - this measure is readily adaptable to tne planning configuration of this occupancy

MEASURE 'L' - AREAS OF REFUGE (with areas of refuge located in pairs or duplicate groups of refuge at every fifth storey)

Description of Measure:



1. Stairshaft and fire fighters' elevator shaft protected by area of refuge or vestibule (2L(11)).*

   Door to outdoors in each stairshaft held open during a fire emergency (2L(14)).

   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that storey (2L(15)).

   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2L(15)).

2. Two areas of refuge pressurized during a fire emergency (see Figure 14 for area of refuge every fifth storey), except that in buildings of Group C major occupancy more than 75 m in height, the areas of refuge are located on each storey (2L(10)).

3. No special protection against smoke for elevator shafts or vertical service spaces other than fire fighters' elevator.

4. Fire fighters' elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2L(13)).

   Fire fighters' elevator shaft provided with vent to outdoors at top and bottom during a fire emergency (2L(16)).

   Air moving fans are stopped in a system that serves more than 2 storeys during a fire emergency (2L(19)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 13 Typical floor plan, Measure L

Measure L satisfies NBC Sentence 3.2.6.2.(5) for buildings of Groups A, C, D, E or F, major occupancy classification of any height.

MEASURE 'L' - AREAS OF REFUGE
(with areas of refuge located in pairs or duplicate groups of refuge at every fifth storey)

Description of Measure:

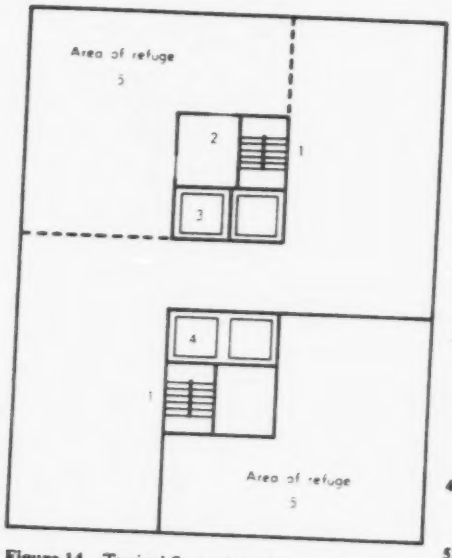


Figure 14 Typical floor plan, Measure L

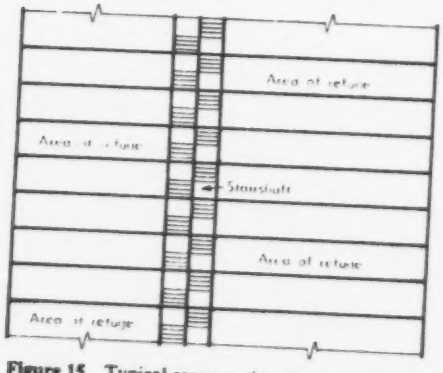


Figure 15 Typical cross section showing areas of refuge on intermediate floors

1. Stairshaft and fire fighters' elevator shaft protected by area of refuge or vestibule (2L(11)).*

   Door to outdoors in each stairshaft held open during a fire emergency (2L(14)).

   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that storey (2L(15)).

   Stairshaft serving floors below the lowest exit level is pressurized during a fire emergency (2L(15)).

2. Stairshaft and fire fighters' elevator shaft protected in intermediate floors by pressurized vestibules (2L(11)).

3. Fire fighters' elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2L(13)).

   Fire fighters' elevator shaft provided with vent to outdoors at top and bottom during a fire emergency (2L(16)).

4. No special protection against smoke for elevator shafts or vertical service spaces other than fire fighters' elevator.

5. Two areas of refuge on each fifth floor pressurized during a fire emergency (2L(10)), or areas of refuge may be staggered on intermediate storeys (see Figure 15), except that in buildings of Group C major occupancy more than 75 m in height the areas of refuge shall be located on each storey.

   Air moving fans are stopped in a system that serves more than 2 storeys in a fire emergency (2L(19)).

*First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Measure L satisfies NBC Sentence 3.2.6.2.(5) for buildings of Groups A, C, D, E or F, major occupancy classification of any height.

MEASURE 'L' - AREAS OF REFUGE

Application:

Measure 'L' provides alternate areas of refuge adjacent to the exit stairs and sized to accommodate the occupants on every floor, or at intervals not exceeding five storeys. These areas may include normally occupied space in the building but must have sufficient quantities of air injected into them in order to maintain tolerable conditions for the occupants during a fire.

In the case where the areas of refuge are spaced at intervals greater than every floor, access routes must be made large enough to allow the occupants to reach the area of refuge within three minutes, and stair shafts and fire fighters' elevators must be protected on intermediate floors by vestibules or by pressurization of the shafts.

MEASURE 'L' - AREAS OF REFUGE

Use Criteria for Groups D & E occupancies:

- Limit the size of the fire:
  - this measure does not actively suppress or contain the fire
- Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
- Control movement of smoke:
  - smoke is not permitted to enter the designated area of refuge
- Dependence of mechanical reliance:
  - the mechanical reliance is similar to other pressurization systems
- Complexity of system required to achieve results:
  - the system is complex to the degree that normal operating systems must be controlled to direct pressurization of designated areas only
- Complexity of user knowledge expected:
  - the use of this sytem requires special knowledge on the part of the occupant and the fire service
- Dependency on emergency power:
  - pressurization of the areas of refuge is dependent upon continued electrical power

MEASURE 'L' - AREAS OF REFUGE

Use Criteria for Groups D & E occupancies:

- Redundancy:
  - this measure is specifically designed as a smoke control measure and has no redundant attributes

- Design/Installation experience:
  - no use history of this measure was found

- Testing/Maintenance experience:
  - no use history was found to establish comment

- Response of occupant:
  - when alternate areas are provided at intervals of five floors, it may be difficult to convince the occupants to re-enter the building at these points. This application of the measure seems to require the active training of occupants and is therefore questionable unless the effectiveness of this training can be demonstrated.

- Suitability to building occupancy:
  - in terms of the multi tenancy flexible planning requirements of this occupancy, the concept of dedicating an area of floor as a separated area of refuge is unacceptable.

MEASURE 'L' - AREAS OF REFUGE

Use Criteria for Group C (hotel) occupancies:

- ☐ Limit the size of the fire:
  - this measure does not actively suppress or contain the fire
- ☐ Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
- ☐ Control movement of smoke:
  - smoke is not permitted to enter the designated area of refuge
- ☐ Dependence of mechanical reliance:
  - the mechanical reliance is similar to other pressurization systems
- ☐ Complexity of system required to achieve results:
  - the system is complex to the degree that normal operating systems must be controlled to direct pressurization of designated areas only
- ☐ Complexity of user knowledge expected:
  - the use of this sytem requires special knowledge on the part of the occupant and the fire service
- ☐ Dependency on emergency power:
  - pressurization of the areas of refuge is dependent upon continued electrical power

MEASURE 'L' - AREAS OF REFUGE

Use Criteria for Group C (hotel) occupancies:

- Redundancy:
  - this measure is specifically designed as a smoke control measure and has no redundant attributes

- Design/Installation experience:
  - no use history of this measure was found

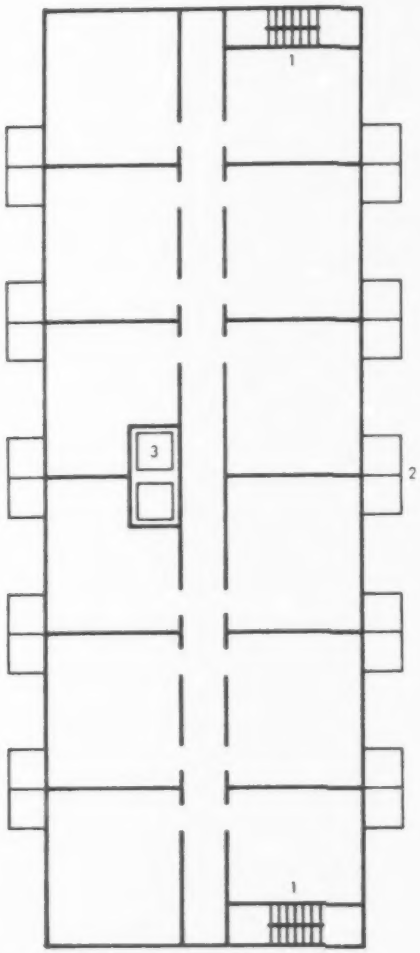
- Testing/Maintenance experience:
  - no use history was found to establish comment

- Response of occupant:
  - when alternate areas are provided at intervals of five floors, it may be difficult to convince the occupants to re-enter the building at these points. This application of the measure seems to require the active training of occupants and is therefore questionable unless the effectiveness of this training can be demonstrated.

- Suitability to building occupancy:
  - this measure is adaptable to the planning configuration of this occupancy

MEASURE 'M' - BUILDING WITH BALCONIES

Description of Measure:



1. Door to outdoors in each stairshaft held open during a fire emergency (2M(2)).*
   Stairshaft serving floors below the lowest exit level is separate from stairshaft serving floors above that level (2M(3)).
   Stairshaft serving floors below the exit level is pressurized during a fire emergency (2M(3)).
2. Each suite provided with a balcony (NBC 3.2.6.2.(8)).
3. Elevator shaft terminates not lower than the first floor below the lowest exit storey or has elevator vestibules in every storey below the lowest exit storey (2M(4)).
   Air moving fans are stopped in a system that serves more than 2 storeys in a fire emergency (2M(5)).

**First number indicates Section number. Letter indicates Measure. Last number indicates number of Sentence in that Measure.

Figure 16 Typical floor plan, Measure M

Measure M satisfies NBC Sentence 3.2.6.2.(8) for buildings of Group C, major occupancy classification that are not more than 36 m high.

SUMMARY DESCRIPTION: SMOKE CONTROL MEASURES

SCOPE

For the purpose of this study the requirements apply to:

Groups D & E – buildings over 36m, or over 18m where

$$\frac{\text{occupant load}}{\text{total units of exit width}} > 300$$

Group C – Hotels – buildings over 18m

APPLICATION PER NBC

(1) No of occupants is less than 2.6 times the area of stairwells in m^2

(2) Separate smoke control zones must be located on each floor

MEASURES FOR SMOKE CONTROL		GROUP C				GROUP D,E		OBJECTIVE						FEATURES					OPTIONS FOR OCCUPANTS			
		Any height	Less than 75m	Less than 75m(1)	Less than 36m with balconies	Any height	Less than 75m(1)	Limit size of fire	Limit movement of smoke into: All floor areas	Stair shafts above lowest exit level	Stair shafts below lowest exit level	Areas of refuge	Fire fighters' elevator	(3) Where vestibules are vented these measures are independent of continuous operation of mechanical equipment: Independent of continuous operation of mechanical equipment	Action to be taken by operator is independent of fire location	Doors to stairs and elevator shafts are protected from direct exposure to fire	Escape routes from room adjacent to fire are protected from smoke	Provides for dilution of smoke that may enter protected shafts	Occupants of fire floor exit to street – other occupants remain until advised	Occupants of all floors exit to street	Occupants move to other smoke control regions (areas of refuge) until advised	Occupants remain until advised –prepare to move to balconies
FULLY SPRINKLERED	A	●	●	●	●	●	●	●			●			●	●				●			
OPEN CORRIDOR	B	●	●	●	●	●	●		●	●	●		●	●	●	●	●		●			
OPEN CORRIDOR	C			●	●		●			●	●		●	●	●	●	●			●		
PROTECTED VESTIBULE	D	●	●	●	●	●	●		●	●	●		●	(3)	●	●	●	●	●			
PROTECTED VESTIBULE	E			●	●		●			●	●		●	(3)	●	●	●	●		●		
SHAFT PRESSURIZATION	F	●	●	●	●	●	●		●	●	●		●		●			●	●			
SHAFT PRESSURIZATION	G			●	●		●			●	●		●		●			●		●		
FULLY PRESSURIZED	H	●	●	●	●	●	●		●	●	●		●					●	●			
CORE PRESSURIZATION	I	●	●	●	●	●	●		●	●	●		●		●	●	●	●	●			
CORE PRESSURIZATION	J			●	●		●			●	●		●		●	●	●	●		●		
VERTICALLY DIVIDED	K	●(2)	●	●	●	●	●			●	●	●	●	3)	●	●					●	
AREA OF REFUGE	L	●(2)	●	●	●	●	●			●	●	●	●		●	●		●			●	
BALCONIES	M				●						●			●	●	–	–	–				●

MEASURE 'M' - BUILDING WITH BALCONIES

Application:

There is no experience with the use of Measure 'M' in Groups D and E buildings, and very limited experience in hotel buildings of Group C occupancy.

MEASURE 'M' - BUILDING WITH BALCONIES

Use Criteria for Group C (hotel) occupancies:

- ☐ Limit the size of the fire:
  - this measure does not actively suppress or contain the fire
- ☐ Detection/Alarm:
  - detection/alarm is not an inherent feature of this measure
- ☐ Control movement of smoke:
  - the movement of smoke is not controlled
- ☐ Dependence of mechanical reliance:
  - the measure is independent of mechanical reliance
- ☐ Complexity of system required to achieve results:
  - the measure is not complex
- ☐ Complexity of user knowledge expected:
  - the measure is relatively the most simple in terms of designed results
- ☐ Dependency on emergency power:
  - the measure is not dependent on emergency power
- ☐ Redundancy:
  - the measure has no redundant attributes

MEASURE 'M' - BUILDING WITH BALCONIES

Use Criteria for Group C (hotel) occupancies:

- Design/Installation experience:
  - there is a minimal amount of experience with this measure

- Testing/Maintenance experience:
  - testing is simply a case of observation that the balcony can be accessed
  - there is almost no maintenance required

- Response of occupant:
  - the occupant response is straightforward and simple

- Suitability to building occupancy:
  - the measure is readily adaptable to the planning configuration of this occupancy

EVALUATION OF FUNCTIONS AND MEASURES

In order that we could draw conclusions from the study of the existing requirements, in terms of the application and experience, the following evaluation charts (Figures 1 to 6 inclusive) were drawn.

The evaluation of the functions of the life safety requirements of Subsection 3.2.6 and the applicable smoke control measures is intended to priorize them. The listing is a summarization of our best interpretation of the results of the interviews, reading, and study carried out for this report.

Figure 1 illustrates the evaluation of the importance of the functions of the life safety requirements of Subsection 3.2.6 when compared against one another.

Figure 2 is a bar chart illustrating the importance of the functions of the life safety requirements in descending order.

Figures 3 and 5 illustrate the evaluation of the reliability of the smoke control measures compared against one another in terms of our evaluation of their capability of meeting the important life safety functions illustrated in figures 1 and 2 and the study of the objectives and reliability criteria.

Figure 3 evaluates the measures for Groups D and E occupancies, Figure 5 for Group C hotel occupancy. Only measures deemed applicable to the occupancy were evaluated.

Figures 4 and 6 are bar charts illustrating the reliability of the measures in descending order.

EVALUATION OF FUNCTIONS

Limit size of fire	9
Limit smoke movement into floor areas	3
Limit smoke movement into shafts	4
Detect fire	8
Alert occupants	7
Alert fire department	6
Provide access for fire fighters	5
Provide smoke venting	2
Provide emergency power	0
Provide communications	1

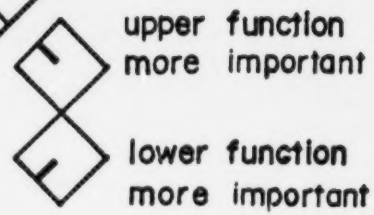


fig. 1

BAR CHART: EVALUATION OF FUNCTION

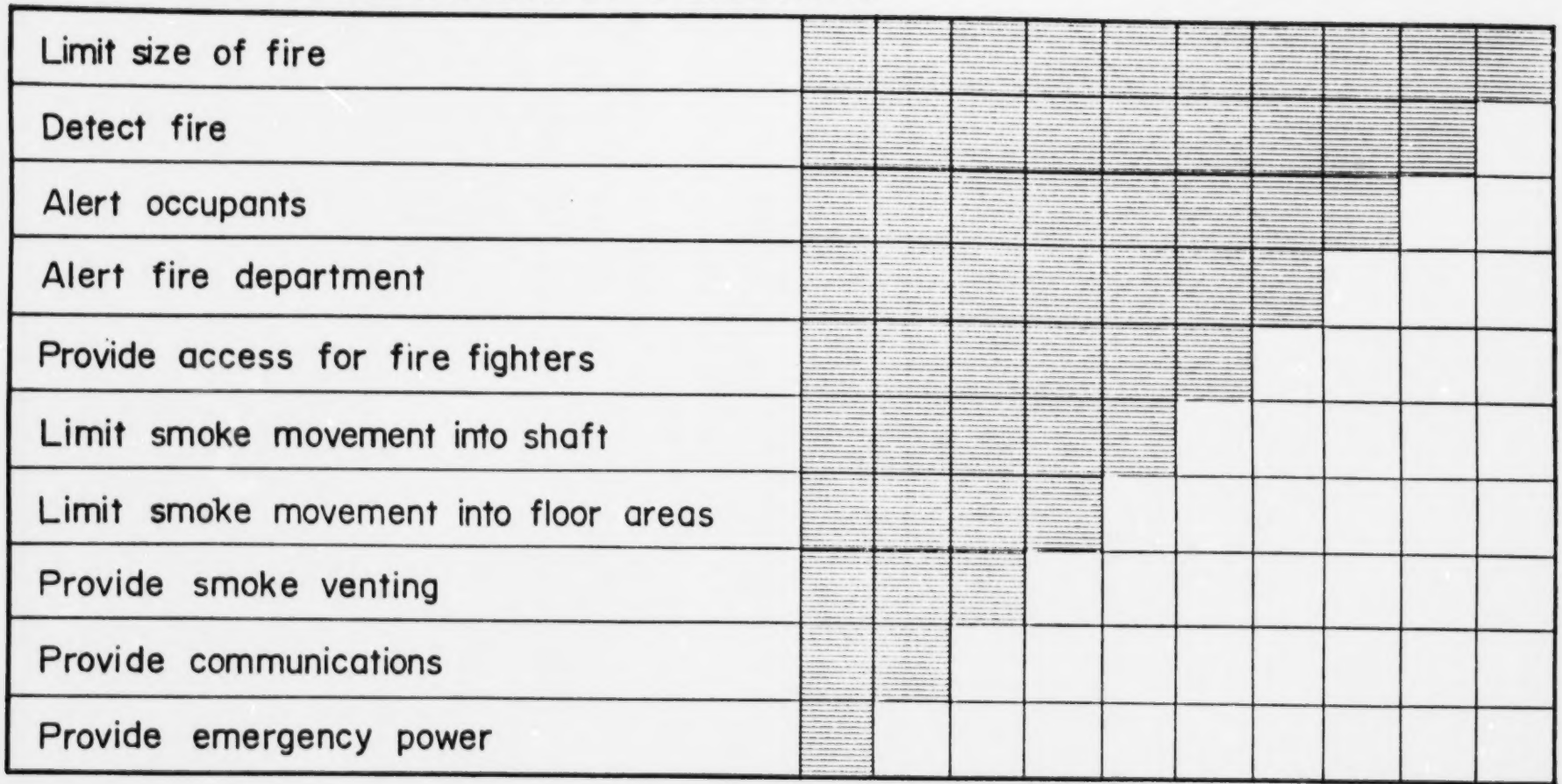
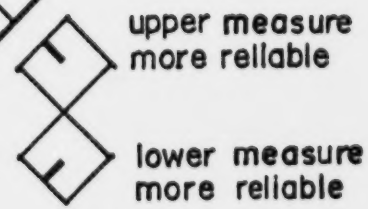


fig. 2

EVALUATION OF MEASURES-GROUPS D&E

A	Fully sprinklered building	9
D, E	Vented vestibules	8
D, E	Pressurized vestibules	6
F	Pressurized shafts - over 75 m	1
G	Pressurized shafts - under 75 m	5
H	Fully pressurized building	2
I, J	Pressurized core	3
K	Divided building - vented vestibule	7
K	Divided building - pressurized vestibule	3
L	Areas of refuge	0



Note: Measures totally inappropriate to occupancy are excluded from evaluation

fig. 3

BAR CHART: EVALUATION OF MEASURES-GROUPS D&E

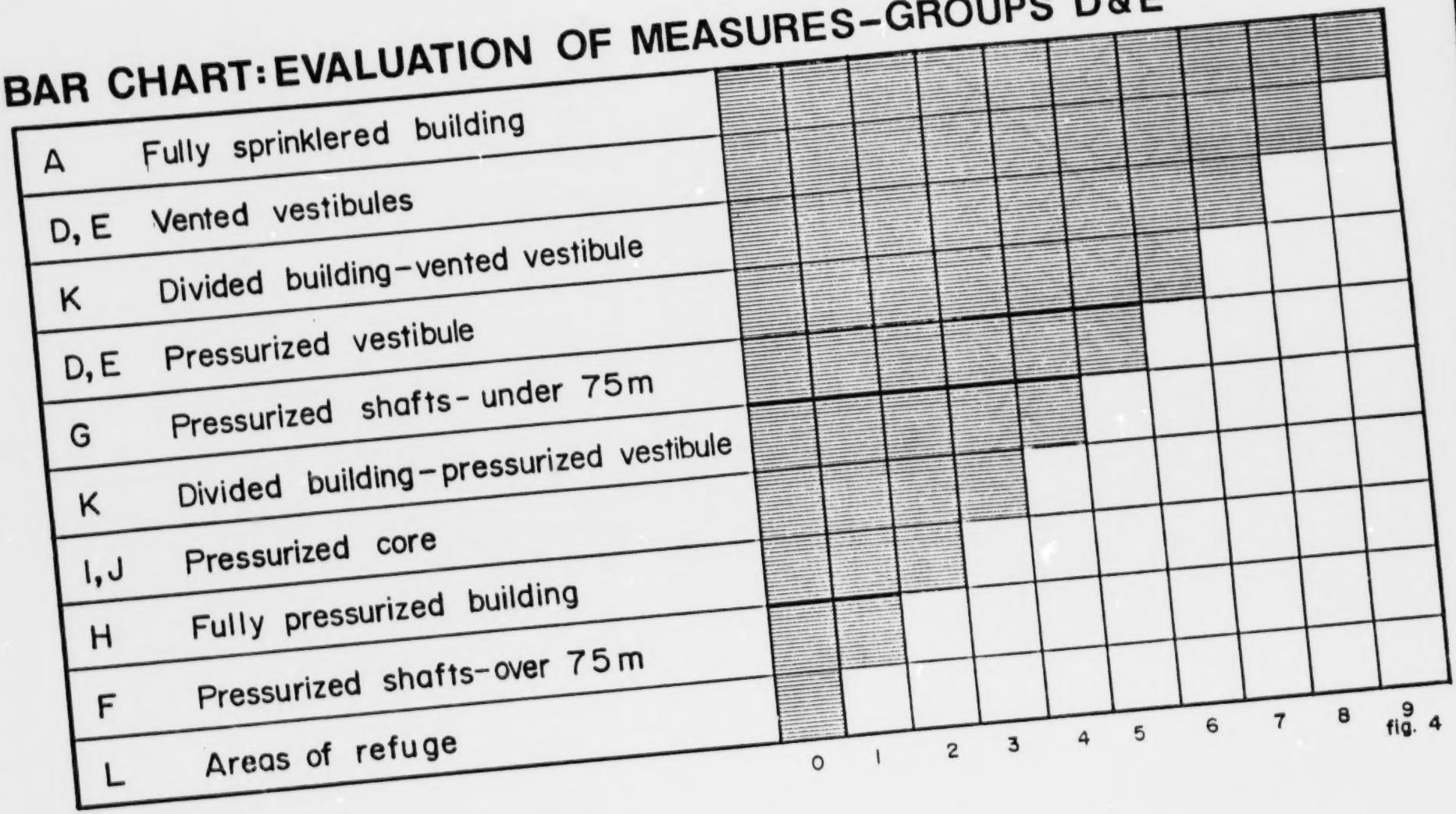
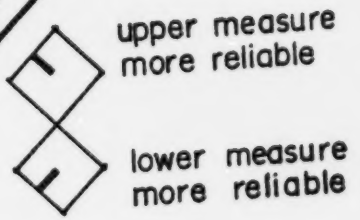

A Fully sprinklered building
D, E Vented vestibules
K Divided building-vented vestibule
D, E Pressurized vestibule
G Pressurized shafts- under 75m
K Divided building-pressurized vestibule
I, J Pressurized core
H Fully pressurized building
F Pressurized shafts-over 75m
L Areas of refuge
0 1 2 3 4 5 6 7 8 9

fig. 4

EVALUATION OF MEASURES-GROUP C (HOTELS)

A	Fully sprinklered building	9
D, E	Vented vestibules	7
D, E	Pressurized vestibules	5
F	Pressurized shafts	1
G	Pressurized shafts-under 75m	2
I, J	Pressurized core	3
K	Divided building-vented vestibule	6
K	Divided building-pressurized vestibule	4
L	Areas of refuge	0
M	Balconies	8



Note: Measures totally inappropriate to occupancy are excluded from evaluation

fig. 5

BAR CHART: EVALUATION OF MEASURES-GROUP C(HOTELS)

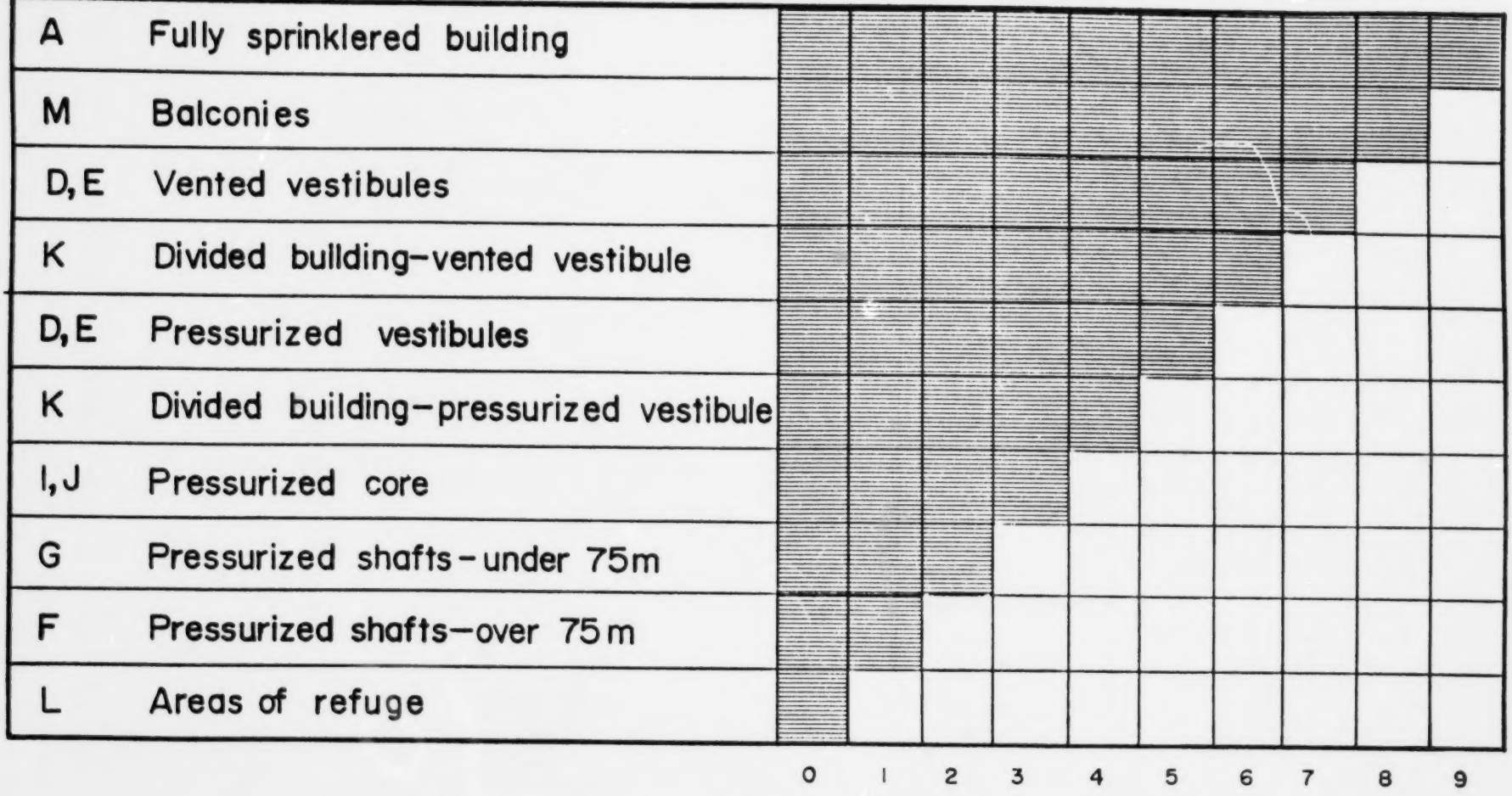

A Fully sprinklered building
M Balconies
D, E Vented vestibules
K Divided building-vented vestibule
D, E Pressurized vestibules
K Divided building-pressurized vestibule
I, J Pressurized core
G Pressurized shafts - under 75m
F Pressurized shafts-over 75 m
L Areas of refuge
0 1 2 3 4 5 6 7 8 9

fig. 6

COST COMPARISON OF MEASURES

General:

To develop the economic impact of the existing measures and to draw relative comparisons as to their cost effectiveness in terms of their reliability, cost estimates to implement the measures were made. The cost of the measure expressed in the summaries is a percentage of the total construction cost of the building.

The loss of rentable area is expressed as a percentage of the total rentable floor area.

COST COMPARISON OF MEASURES

Assumptions:

In preparing the cost estimates for the two cases illustrated, the following assumptions have been made:

- cost figures reflect only the additional requirements for high buildings.
- stair shafts do not penetrate to the level below an exit level.
- elevators do not penetrate below the level of one storey below an exit level.
- in calculating the % loss of rentable area in office buildings, it was presumed that the building core was designed as efficiently as possible and that any additional space requirement of the individual smoke control measure reduced rentable area.
- in developing the plans of a hotel building, extra floor space required to implement the smoke control measure is recorded as a cost to that measure and not a loss of area.
- only measures deemed applicable to the occupancies studied were compared.

COST COMPARISON OF MEASURES

Cost Comparison - Measures for Groups D & E occupancies:

To develop costs for these occupancies, a typical office building of approximately 400,000 sq.ft. in area was analyzed.

The comparative results are:

Measure		Cost of Measure (% of total cost)	Percent Loss of Rentable Area
A	Fully Sprinklered	2.1%	none
D,E	Protected Vestibule (pressurized)	1.9%	0.51%
D,E	Protected Vestibule (vented)	1.9%	0.51%
F,G	Pressurized Shafts	1.4%	none
H	Fully Pressurized	1.3%	none
I,J	Pressurized Core	1.6%	0.21%
K	Vertically Divided	2.6%	0.21%
L	Areas of Refuge	1.2%	0.21%

COST COMPARISON OF MEASURES

Cost Comparison - Measures for Group C (hotel) occupancies:

To develop costs for this occupancy, a typical hotel building of approximately 480 suites was analyzed.

The comparative results are:

Measure		Cost of Measure (% of total cost)
A	Fully Sprinklered	3.39%
D,E	Protected Vestibules (pressurized)	2.52%
D,E	Protected Vestibules (vented)	4.84%
F,G	Pressurized Shafts	1.08%
I,J	Pressurized Core	1.21%
K	Vertically Divided	2.08%
L	Area of Refuge	1.80%
M	Balconies	*

*When installed specifically for the purposes of the measure, the cost is the most expensive. When installed for other reasons and utilized as the measure, the cost is the least expensive.

CONCLUSIONS

CONCLUSIONS

Limit the Size of the Fire:

This study has reached the conclusion that the most effective method of limiting the danger to the occupants of high commercial buildings is to limit the size of the fire.

Limiting the size of the fire either by means of effective compartmentation such as the rooms or suites in hotels or a direct suppression system such as sprinklers has an impact on reducing the amount of smoke produced which may then travel through all parts of the building.

Sprinklering is the only smoke control measure alternative described in the A.C.N.B.C. booklet "Measures for Fire Safety" that actively limits the size of the fire.

A sprinkler system is merely a plumbing system to distribute water. Sprinklers typically activate by means of a fixed temperature fusible element. These methods of activation rely only on the heat of the fire and are automatic. The reliance on heat for activation has one additional benefit. It is not prone to false or nuisance alarms as are typical with smoke or flame detection systems.

The water which the sprinkler discharges onto the fire comes through the sprinkler piping system. Since it is a water distribution system it works on the principle of hydraulics, thereby requiring only that an adequate water supply be provided. This water supply is typically provided by connection to street mains augmented by pumps where City pressure is not adequate to overcome the loss in pressure due to building elevation.

Thus, the system requires only that the pump operate and, that any control valves in the system be open. In that regard, all valves should be electrically supervised to ensure that they are maintained in the open position and, emergency power should be provided to the fire pump to ensure that it will operate in the event of failure of the normal building electrical power. Thus, if the system is installed in accordance with the installation requirements for sprinkler systems

CONCLUSIONS

Limit the Size of the Fire:

and an adequate water supply is installed and tested, we have a high level of assurance that the system will perform as intended under fire conditions.

Contrary to this, other fire protection systems typically require installation of detection devices which are in turn connected to an annunciator panel which sounds a fire alarm through an annunciation system. All of these require proper installation and are subject to the reliability problems inherent with electrical and mechanical devices. Also, with respect to mechanical smoke control systems, design problems and environmental conditions may render these systems ineffective even if they operate as intended. Therefore, total reliance on mechanically and electrically based systems for fire safety in high rise buildings is not appropriate. Control of fire and smoke by means of compartmentation or sprinklers will, however, provide the level of performance which is needed in high rise buildings where evacuation of all building occupants may be impractical or not possible.

Both sprinklers and compartmentation will control the fire thereby limiting fire spread in the building and controlling the generation of smoke.

The excellent fire record associated with high rise apartment structures attest to the effectiveness of compartmentation for fire and smoke control. A series of fire tests conducted on nursing homes has likewise illustrated that fire can be expected to be contained to the room of fire origin where the room size will, in itself, limit the amount of combustion available and the enclosing walls of the room are complete, i.e., the windows and doors are closed.

A recent series of fire tests was conducted in a six-bed hospital room in the U.K. For the first three tests, a fire was ignited in one of the beds with the building ventilation system in its normal operating mode. In all of these tests, the fire was confined to the bed. Environmental conditions within the room, however, were such that other patients within the room would have had to have been evacuated in the early stages of the fire.

CONCLUSIONS

Limit the Size of the Fire:

Where this test was repeated with a high level of ventilation, the fire intensity increased and the room was quickly totally involved in the fire condition.

This test was repeated where a modified sprinkler system was installed. In that case, a single sprinkler was installed over each of the beds. In those tests, the sprinkler operated and controlled the temperature and toxic gases within the room such that the remainder of the room could remain occupied during the entire duration of the fire. In another series of fire tests recently completed in Florida, a sprinkler system utilizing a sprinkler designed for fast operation also controlled the fire within the test room such that the room could be occupied during the entire fire exposure. The sprinkler used for this test was equipped with a fast operating fusible link thereby decreasing the time for the sprinkler to operate.

These tests illustrate the effectiveness of both compartmentation and sprinklering at controlling fires and thereby limiting the amount and extent of smoke spread. Compartmentation is effective where the fire area is small and there are adequate barriers to prevent the spread of fire and smoke to adjacent compartments. Sprinklers are effective where they control or extinguish the fire. It is obvious from the sprinkler tests referenced above that if occupancy could be maintained within the room of fire origin, that other occupants within the building would not be endangered by the fire condition. While a sprinkler system as designed for a typical commercial high rise building may not be as responsive to a fire condition as that indicated in the above tests, it will be sufficiently responsive to control or extinguish the fire thereby limiting the amount of smoke generation. While it may not be safe to remain in the room of fire origin, the smoke will be sufficiently dissipated that it would not endanger occupants in other parts of the building. For that case, high rise smoke control objectives will be achieved by the sprinklers.

CONCLUSIONS

Limit the Size of the Fire:

Coupled with the basic parameter of achieving the goal of the smoke control, sprinklers provide an active assist to fire fighting and by limiting the size of the fire have the potential of reducing the secondary losses of fire associated with injury and property loss.

CONCLUSIONS

Detect the Fire and Notify the Fire Department and Occupants:

Next to limiting the size of the fire, the most important conclusion of this study is that immediate notification of the fire department and occupants of a potential fire is paramount. One common thread, when one reads the reports of multiple life loss fires in high commercial buildings, is the failure of notification for one reason or the other: either failure of the electrical/mechanical system through faulty installation or maintenance, or more predominantly through failure of the human response element when notification is not either direct or proprietory.

All fire experts appear to agree that the critical element in a fire emergency is the reduction of the time required to detect the fire to the time when water can be put on it.

One aspect of sprinklers is that they not only act to suppress the fire but they detect and alarm simultaneously.

CONCLUSIONS

Certain smoke control measures cannot be expected to reliably achieve their designed goal:

If we had found general agreement and positive feedback regarding experience with the existing measures from the user groups interviewed and the numerous articles and reports discussing their implementation, we would be confident in supporting their continued use as written in the A.C.N.B.C. booklet "Measures for Fire Safety in High Buildings"; however, we did not find the general agreement or feedback to do so.

In our study of the existing requirements we were able to identify problems perceived by the various user groups against a set of criteria established to provide a broad background of comment. Our evaluation of that criteria shows that a number of the measures cannot be expected to reliably achieve their designed goals:

- there are very real problems with a number of the measures in that they cannot practically be adapted to the planning and use criteria of the occupancy. This fact alone means that a number of the more reliable and straightforward measures are not considered and the less reliable and more complex measures are utilized. An example of this is the lack of use history of vented vestibule protection in favour of complex pressurization systems requiring special knowledge and heavy reliance on continued mechanical and electrical operation.

- reports and interviews with fire service officials show a high number of failures of pressurization systems without extensive re-testing. The re-testing becomes so "dragged out" that in the end there is doubt as to whether the system was in fact made operational.

CONCLUSIONS

Certain smoke control measures cannot be expected to reliably achieve their designed goal:

- a number of the relatively inexpensive measures are highly complex and require a degree of special knowledge which may well be beyond the constraints of present users. Combined with any special knowledge which provides a large potential for human error is the inherent complexity of these systems and the need for a number of components to all work correctly for the achievement of the designed goals.

- the fact that there is a lack of historical experience with pressurization measures in actual fire conditions and thus no use convention provides fuel to the doubts of the fire service that the measures will in fact achieve their goals. It should be remembered that all results to date (and these as we have found are not entirely satisfactory), are on the basis of cold smoke testing and the components have not been tested in a fire condition as a total system.

- the potential hazard associated with the miscue of the correct functioning of the measure has resulted in the lack of confidence of the eventual user and responsible party: the fire service.

None of the pressurization measures address the basic concern of life safety in a fire emergency: limit the size of the fire.

With due respect to the objectives of these measures and to the many well executed installations we could not find any consensus of the anticipated success of their use in a fire condition. Unfortunately for the authors of this study but fortunately for the occupants of high non-compartmented buildings there has been no fire experience with buildings incorporating the measures.

CONCLUSIONS

Certain smoke control measures cannot be expected to reliably achieve their designed goal:

The opinions of the designers, the code authorities, the fire fighters, and the building owners we spoke to, are all based on real concerns they have met in their daily work of designing, commissioning, fire planning, and operating high buildings.

Their inability to arrive at any consensus of reliability is in our opinion, just cause to stop their use. To stop it before a serious error in judgement is made and lives are lost through no fault of anyone's best intentions.

CONCLUSIONS

The Human Factor

"As we adopt more stringent fire protection systems for high rise structures (and as that goes for any structure), we must not overlook the human factors".

This quotation taken from an article describing a recent multiple life loss fire in a modern hotel incorporating smoke control features effectively summarizes the concerns our study team found during the phases of this report.

The reliability criteria we used in evaluating the effectiveness of existing smoke control measures encouraged responses relating to the effectiveness of occupants, owners, and the fire service to respond to limiting the danger to smoke.

In general our findings were:

- the more complexity built into the system the less confident was the reaction of the user of the system. We agree that it can be said that training and use experience could overcome what can be perceived to be a "reaction to something new" but in the context of the procedures of the fire service and building management we believe the reaction is valid. "Keep it simple stupid" should be the principle of design and use. As an example imagine the problems of an occupant who would require differing special knowledge of his expected actions in the place he lives, works, and plays or the effort required by the fire service to keep track of the numerous fire protection options in the buildings in their jurisdiction and the potential ongoing changes.

CONCLUSIONS

The Human Factor

- a number of the measures anticipate a response of the occupant which in terms of normal behaviour demands special training and education. It is difficult to believe that this can ever be accomplished realistically in the transient occupation of high commercial buildings. It is even more difficult to comprehend that people can be expected to respond to area of refuge measures which require them to re-enter the building or strange floors and be sealed in smoke and fire protected areas.

- numerous reports of failure and delay of reporting a fire which incurred further injury, loss and in some instances deaths. It is difficult to imagine but many devices which in theory appear adequate in practice are defeated by human reaction even when done with the best of intentions.

  Probably the most poignant example of this is a recent multiple loss fire when the shaft pressurization and vestibule protection was pre-empted by someone with the best of "intentions" when the doors were propped open with the building fire extinguishers allowing smoke to fill the building and endanger occupants.

We are not suggesting that all human reactions are negative in respect to anticipated action but when recommending any measure for life safety the human factor should be considered.

RECOMMENDATIONS

GENERAL

From the statistics, the life safety records of high-rise commercial buildings is enviable. This is owed in part to the dedication and expertise of people actively involved in the design, construction, management and use of them.

Code writing bodies, building officials, architects, engineers, builders, owners, managers, and the fire service have co-operated over the years to develop design measures specifically to ensure our high-rise commercial buildings are as life safe as possible.

The primary purpose of this study was to review the present requirements limiting the danger from exposure to smoke with the objective of strengthening, if necessary, specific measures to ensure their effectiveness in an economical and practical manner.

The recommendations are specific where we felt our findings point to the need to alter a requirement, and general and fundamental where we perceived the need to bring attention and possibly further study to a particular concern.

We have concluded that it is necessary to recommend changes to the measures to simplify and clarify their application.

The only constant that was evident in our research of many articles and publications, and in our interviews and discussions with authorities having jurisdiction, with building owners and designers, and with the fire service was a notable difference of opinion. The difference of opinion is a result of the perception each group has of its role in the application of the measures.

Those who design and approve are concerned that what is acceptable in theoretical example may in practice not meet its designed goal.

Those who work daily with the operation of the measures have built up a feeling of distrust based on a record of real and perceived problems both with the intended operation of the measure and the interaction with their operating procedures.

GENERAL

Life safety in high buildings is too critical a problem to be left in a state which has room for doubt and differences of opinion.

To simplify and unify the requirements we have addressed our recommendations to:

- minimize the conscious decision of the occupant who should not have to ask "what is my action in this building in case of fire?"

- minimize the various measures and building idiosyncrasies for the fire fighter who may (in a major metropolitan area), have up to 50 high buildings in his area.

- maximize the opportunity for the engineered solution by offering criteria which ensures proper design, evaluation, and operation.

- minimize the effect of an everchanging building environment in terms of tenant changes and occupant turnover.

- maximize the cost effectiveness of the requirements for the benefit of the owner and occupants.

If the findings of this study are in any way able to contribute to the achievement of an even more enviable life safety record, then we feel we will have accomplished our task.

SMOKE CONTROL IN GROUPS D & E (OFFICE & RETAIL BUILDINGS)

Recommendation:

High buildings of Groups D and/or E occupancy should be fully sprinklered and certain requirements discussed hereafter should be relaxed.

Discussion:

The effectiveness of sprinkler systems in controlling and suppressing fire is demonstrated in an Article by W. Robert Powers. This paper reviews the fire experience of sprinklered high rise buildings in New York City. It concludes "The New York experience shows 100% satisfactory operation for high rise office buildings, 98.9 for all high rise buildings and 97.2 for other New York buildings".

Traditionally, automatic sprinkler systems are assigned a .792 to .982 reliability depending upon the occupancy protected. This range is based on automatic sprinkler performance data compiled by the National Fire Protection Association. A review of the 1970 edition of the NFPA Automatic Sprinkler Performance Tables reveals:

Total Number of Fires	81,425
Total Satisfactory Sprinkler Performance	78,291
Total Unsatisfactory	3,134
Total Satisfactory Percent	96.2
Reliability of a Sprinkler System	.962

Discussion:

A review of the causes of the 3,134 unsatisfactory performance reveals:

Cause	Number of Fires
Water shut off	1,110
Partial protection	254
Inadequate water supplied	311
System frozen	44
Slow operation	56
Defective dry pipe valve	53
Faulty building construction	187
Obstruction to distribution	256
Hazard of occupancy	424
Exposure fire	52
Inadequate maintenance	262
Antiquated system	65
Miscellaneous and unknown	60

Of these, the presence of a fully supervised, hydraulically calculated, automatic sprinkler system designed to the hazard presented by the occupancy in the building, matched by a reliable, calculated water supply, and coupled with an adequate maintenance programme eliminates many of the above potential causes of sprinkler system failure. Based on a review of the detailed causes of sprinkler system failure in Table #4 of the NFPA Performance Tables, the remaining 702 potential causes of failure could be:

Cause	Number of Fires
Water shut off	556
Inadequate water supplied	26
Slow operation	19
Obstruction to distribution	21
Hazard of occupancy	10
Inadequate maintenance	10
Miscellaneous and unknown	60

Discussion:

This leads to the following reliability for a sprinkler system:

$$\frac{81,425 - 702}{81,425} = .9914$$

Reliability data was also developed in the book: "Automatic Sprinkler Performance in Australia and New Zealand for 1886 - 1968" by H.W. Marryatt. In this study of 5,734 fires, there were 14 unsatisfactory sprinkler performances, the causes of which were:

Cause	Number of Fires
Severe external exposure	4
Partial sprinkler protection	4
Explosions	3
High fire loading	1
Inadequate water supply	1
Faulty building construction	1

This leads to the following reliability for a sprinkler system:

$$\frac{5,734 - 14}{5,734} = .9975$$

The presence in this building of a fully supervised hydraulically calculated sprinkler system designed for the hazard of the occupancy, a reliable calculated water supply and an adequate maintenance programme eliminates all of the above potential causes of sprinkler system failure, except for the three in the explosions category.

This leads to the following reliability for a sprinkler system:

$$\frac{5,734 - 3}{5,734} = .9995$$

SMOKE CONTROL IN GROUPS D & E (OFFICE & RETAIL BUILDINGS)

Discussion:

It should be noted that in Australia and New Zealand, it is required by law that sprinkler systems have a water flow alarm connected to the fire department. This may account for the relatively few unsatisfactory performances in Australia.

The reliability record of sprinklers is astonishing when considering the reliability history of other fire protection systems incorporated in high rise buildings. Specifically, we have concern that the quality of commission testing and maintenance presently performed on high rise fire protection systems is not adequate to ensure that the system will perform in the manner expected for that system. Many of the failure modes are mechanically or electrically based. As such, they are not inherent in the design and installation of automatic sprinkler protection.

Based on their proven reliability and effectiveness, it is appropriate to encourage their use in a high rise commercial building, where an uncontrolled fire could have consequential results. Similarly, it is appropriate to relax certain requirements in the Code where this protection is provided.

Common Risers:

When considering the proposal for mandating the sprinklering of these structures, it must be emphasized that the mandated design requirements are those of the recognized independent authority, the National Fire Protection Association (NFPA). Therefore, the Code should reference NFPA 13 - 1980, "Standard for the Installation of Standpipe and Hose Systems" for the design requirements of the sprinkler and standpipe systems. These Standards permit the automatic sprinkler system and the standpipe and hose system to be combined and hydraulically designed. Also, these Standards do not mandate the requirements of on-site water storage for fire protection.

In addition, consistent with the 1980 National Building Code, it is recommended that the total water supply not be required to exceed 500 gpm (30 L/s).

SMOKE CONTROL IN GROUPS D & E (OFFICE & RETAIL BUILDINGS)

Discussion:

Roof Ratings:

Full scale fire tests have been conducted to determine the effectiveness of automatic sprinkler protection in reducing temperatures of structural steel members. One series of tests was conducted by Factory Mutual Research Corporation on library stacks, another by Underwriters' Laboratories, Inc. Both show that automatic sprinklers will maintain temperatures well below the level which would endanger the integrity of structural steel members. One of the tests which sprinklers must pass in order to be UL listed, is the Wood-crib test. In this test, a 350 lb. wood crib, which was Heptune continuously applied, is ignited in the test room and the time and ceiling temperature is recorded. To be listed by UL, a sprinkler must successfully maintain ceiling temperatures below that of the critical temperature of exposed steel until the end of the 30 minute test. Since it is a function of the sprinkler system to maintain temperatures of roof steel below their critical temperatures, it is appropriate that we recognize this by deleting the fire resistance rating for roof assemblies in sprinklered buildings.

Recognizing this, the Associate Committee of the National Building Code of Canada has proposed a change for the 1985 National Building Code to extend the waiver for roof assemblies to have a fire resistance rating apply to all sprinklered buildings regardless of height and occupancy.

Dampers:

A properly designed and installed sprinkler system will control temperatures within the area of fire origin. Recognizing this, Building Codes reduce or eliminate the requirement for fire resistance ratings on construction elements of a building. This reduction in rating is in recognition of the sprinkler's ability to control or extinguish a fire, thereby eliminating the need of the structural element to contain fire as is required where fire control is achieved by compartmentation.

SMOKE CONTROL IN GROUPS D & E (OFFICE & RETAIL BUILDINGS)

Discussion:

Openings through fire separations are required to be provided with closures. In the case of duct openings, these closures typically consist of fire dampers. Our experience indicates that these fire dampers are often not properly installed and, their reliability under fire conditions is subject to question. In the case of the sprinkler fire compartment, there does not appear to be a necessity for these dampers since the duct itself would provide a sufficient fire and smoke separation for the wall or ceiling opening where sprinklers control temperatures. As is demonstrated in the tests involving steel roof decks, the sprinklers will effectively reduce temperatures below that which would endanger the integrity of the steel roof deck members. Likewise, these sprinklers will maintain temperatures such that steel ducts will maintain their integrity during fire conditions, thereby eliminating the need for a fire damper. In that case, the duct itself will prevent the passage of fire and smoke spread from one compartment to another via the duct.

Shaft Ratings:

Code Requirements: The 1980 NBC requires vertical shafts to be constructed having the same fire resistance rating as the floors they penetrate.

Proposed Change: Reduction in shaft ratings to that formerly required under the National Building Code and which are presently required under the 1975 Ontario Building Code.

Discussion: This recommendation is based on the fact that the changes to shaft ratings in the 1980 Code were not precipitated by adverse experience and that increasing the rating for a sprinklered building is not justified.

Precedence:

- The 1975 Ontario Building code, or 1981 Alberta Building code, and
- The ordinance amending Section 1807 of the 1975 Uniform Building Code for the City of Seattle and King County permits vertical shafts other than stairway enclosures and elevator shafts to be reduced to 1 hr. when sprinklers are installed within the shafts at alternate floors.

SMOKE CONTROL IN GROUPS D & E (OFFICE & RETAIL BUILDINGS)

Economic Impact:

Our cost comparison analysis of the existing measures indicates that a fully sprinklered building is relatively one of the more expensive measures.

The impact of the recommendation to fully sprinkler D and E occupancies and the relaxation of the requirements described reduces the total cost of the sprinkler measure. A savings of less than 1% of the construction cost will bring this recommendation in line with the least expensive measure compared.

SPRINKLERING SUBSIDIARY OCCUPANCIES IN GROUP C HOTELS

Recommendation:

That Sentence 3.2.6.6.(1)(a) be revised to read as follows: every storey or part thereof intended for a Group A, Group D, Group E, or Group F Division 1, 2, or 3 occupancy - and that Sentence 3.2.6.6.(1)(b) be deleted.

Discussion:

The intent of this revision is to ensure that all non residential subsidiary occupancies of a recreational hotel are sprinklered.

In 1977, NFPA published a study of Hotel Fires for the period 1971 - 1974. It was based upon a study of 391 U.S. fires and 57 Canadian fires, all reported as serious.

The fires involved 260 fire deaths (including three fire fighters) and 525 injured (319 fire fighters).

The high loss of life fires shared a number of common features:

- combustible interior finish and furnishings permitting the propagation of flame and gases;
- unenclosed vertical openings, usually stairways; and large undivided floor areas permitting the spread of flame and gases; and
- the absence of a fire alarm, sprinkler, or detection equipment.

SPRINKLERING SUBSIDIARY OCCUPANCIES IN GROUP C HOTELS

Discussion:

It appears that the problem is not unsimilar to recent ones experienced with covered malls. This is to say that spaces that were created with the intent of no hazardous occupancy, with time, are used for a multiplicity of functions and tend to be highly decorated with a variety of permanent and temporary materials.

From the fire experience record it is evident that multiple life loss fires in hotels were caused by the unchecked and rapid spread of fire in subsidiary occupancies creating untenable conditions of heat and smoke to occupants in the residential occupancy. The efforts of fire fighters to undertake the fire fighting and search and rescue operations were frustrated by the rapid fire spread and tremendous smoke development.

Economic Impact:

While seemingly major, the impact of this recommendation is minimal. We say this because upon examination the additional area requiring sprinklering is a minor percentage of the hotel area.

Further, the additional sprinkler coverage is an extension of a system that is in place and would not require the installation of a total system.

In summary, we feel that, from all the accounts of fire experience we have read the extension of this sprinklering requirement is potentially the most cost beneficial we can make.

SMOKE CONTROL IN GROUP C (HOTEL) BUILDINGS

Recommendation:

High buildings of Group C hotel occupancy should incorporate one of the following alternative measures:

- partial sprinklering to include all floor areas except the suites

  or

- Measures D & E vented vestibule protection for shafts

  or

- Measure M balcony measure

Discussion:

The above recommendation should be read in conjunction with our recommendation to clarify the sprinklering of subsidiary occupancies in hotels.

Coupled with the previous recommendation and the inherent compartmentation of the hotel occupancy the above measures provide effective smoke control measures to limit the danger to smoke.

With the present detection requirements and compartmentation requirements (which includes door closers), it is our opinion that full sprinklering is not cost effective. The sprinklering of the corridor effectively prevents spread of the fire from a corridor ignition which is a concern in hotel occupancies.

The vented vestibule is a very reliable measure which is readily adaptable to a hotel occupancy and would prove to be an effective alternative.

SMOKE CONTROL IN GROUP C (HOTEL) BUILDINGS

Discussion:

Measure 'M' has recently been recommended for extension to Group C buildings of any height by the Use and Occupancy Committee of the National Building Code.

The measure has a high degree of reliability and a straightforward occupant response.

Economic Impact:

We recognize that the alternative measures we have recommended range from the most expensive to potentially the least expensive, however, the evaluation of our criteria of realiability indicates they should be utilized.

The balcony measure of course can be the least expensive if balconies are in fact an inherent part of the building design.

Vented vestibules are an expensive alternative and attempts on our part to recommend the relaxation of other requirements in conjunction with this measure were in vain.

The partial sprinklering we recommend results in an additional sprinklering of the corridors beyond the areas required by our previous recommendation.

When this is combined with a recommendation to relax the requirement for separate standpipe/sprinkler risers this particular measure compares in cost with the least expensive measures illustrated in our cost comparison of the existing measures.

SUBSIDIARY OCCUPANCY

Recommendation:

Sentence 3.2.6.6.(1)(a) should be an exception to the general definition of major occupancy.

Discussion:

There has been concern raised through certain recommendations made in this study that there may be difficulty in applying certain requirements because of the various interpretations of the present definition of major occupancy in the Ontario Building Code.

The present definition for major occupancy says that subsidiary occupancies integral to the major occupancy are deemed to be included in the major occupancy.

It is possible to argue, we believe, that the Group A, D, E, and F occupancies referred to in Sentence 3.2.6.6.(1)(a) could be deemed integral to the Group C Hotel Occupancy and thus not require sprinklering.

The intent of 3.2.6.6.(1)(a) would thus be lost.

We do not believe this was anyone's intention and suggest that an exclusion be added to the definition suggesting that there are specific requirements in the code where the subsidiary occupancy is not deemed to be a part of the major occupancy.

This, we feel, would do two things:

- it would ensure that the intent of discrete requirements in the code such as 3.2.6.6.(1)(a) would be implemented

SUBSIDIARY OCCUPANCY

Discussion:

- it would prevent the potential abuse of subjecting the subsudiary occupancy to the full code requirements which we feel was the original concern and remains valid.

Economic Impact:

This recommendation does not impact on the cost of construction.

EQUIVALENT MEASURES

Recommendation:

Proposed smoke control measures not proscribed in the Code must be subjected to an engineering solution of the highest standard and conditions of acceptance which relate to the capability of the Owner's and fire service's management.

Discussion:

It is our opinion that equivalent smoke control measures be an engineered solution of the highest standard and that any undertaking of the equivalent be subject to the following conditions:

- a demonstrable reliability with redundancy of protection built in to the solution
- confirmation that the building owner manager can provide the necessary on-going supervisory staff to complement the system operation and maintenance
- confirmation that the responsible fire service is capable of providing both the manpower and equipment to fully utilize the features of the measure

We recommend this to hopefully limit the use of sophisticated and thus by their nature, complicated air measures to large complexes where both the fire service and the building management can effectively understand and utilize the measure.

Our experience in talking to both fire fighters and operators is that unless the above conditions are met, the system is not utilized. One tragic example unfolded in a large metropolitan area when we discussed the operation of a control alarm and control facility with the fire fighters. After some discussion regarding the operation of the measure and

EQUIVALENT MEASURES

Discussion:

some very real concerns on our part as to the effectiveness of the utilization of the measure, the fire fighter told us that in all probability, is an emergency he would use only the annunciator and not utilize the panel. This measure is thus refuted, the main is going to rely on his own resources.

A one-off example? No, in one form or another with no discredit to the fire service, who we feel are trying very hard, we found example after example of this. The only examples where a real sense of trust in working with the measures were found, were in sprinklered buildings and in large complexes with trained full time supervisory staff.

Economic Impact:

The impact of this recommendation cannot be determined but we feel strongly that one reason for providing for equivalency is to leave room for even better cost effective measures.

HEATING OF OUTSIDE AIR

Recommendation:

The recommended practice to heat the air supplied for emergency pressurization of shafts and vestibules, as found in the Supplement to the National Building Code 1980, should be revised.

Discussion:

Heated air can be provided on a voluntary basis with no repercussions but it is not demonstratable that it is required for the effective pressurization of a shaft or vestibule.

It was suggested to us that the reason for its inclusion was entirely a concern with the comfort of the occupant evacuating the building. We feel that this will be the least of the occupant's concerns and it is most certainly adding to the cost of the installation.

The only justification for heating the air would be the possible damage through freezing to water lines; however, the method of protection of components subject to freezing should be left to the discretion of the designer/owner.

Economic Impact:

This particular measure only applies to pressurization measures which are provided for under our recommendation regarding equivalent measures.

The effect of this recommendation is to substantially reduce the cost where heating of the air might be considered.

SEPARATION OF BUILDINGS

Recommendation:

The intent of the present requirement contained in Measure 'N' as described in the A.C.N.B.C. booklet "Measures for Fire Safety in High Building 1980" should be written as a requirement in Subsection 3.2.3 of the Code for the separation of buildings.

Discussion:

The intent of Measure 'N' is to ensure that the integrity of the separation of high buildings is maintained. This is accomplished by requiring pressurized or vented vestibules at openings in the building separation. We have confirmed with the advisors of Codes and Standards of NRC that this requirement is an add-on to the smoke control measures utilized for the buildings and is not by itself an optional smoke control measure.

The intent of this requirement would be clearer if written as a means of building separation in Subsection 3.2.3 of the code than as a smoke control measure.

Economic Impact:

This recommendation does not impact on the cost of construction.

COMMISSIONING

Recommendation:

The building code should contain requirements for the procedures of the commissioning of life safety systems for high rise commercial buildings.

Discussion:

"Commissioning" is the act of putting relevant systems into working order and preparing them for active use. As such, it includes:

- the survey and examination, testing, and proving the performance of components, equipment, systems both during and after construction
- adjusting systems to effect efficient and proper performance with proper interaction of all related systems after construction
- the instruction and training of operating staff before occupancy

To achieve the operational performance quickly and correctly under stress of emergency conditions requires the set-up of a comprehensive fire plan including operating schedules and programmes, and the establishment of contingency alternatives. For some projects the fire plan can be very simple, however, for high buildings, the commissioning must include priorities and sequences in order to:

- isolate fire and prevent spread of fire and smoke
- execute evacuation from fire zone
- extinguish fire
- purge smoke

COMMISSIONING

Discussion:

Commissioning requires an understanding of all functional systems including automatic sprinklers, manual fire hose systems, gases such as halon, chemicals such as in automatic and/or manual extinguishers, air distribution and pressure of HVAC systems, and electricity in alarms, starters, etc.

Because of the immense complexity of the building occupancies, the systems provided and the diverse responsibilities, it is essential that when required, proper action will be taken. The procedures of commissioning and acceptance must be addressed to "who, when and how" as well as to "what".

"WHO" - The contractor normally has the singular responsibility for constructing, commissioning and handing over the project. The designer has the responsibility for documenting and instructing the contractor on the interpretation of the design and itent. The approvals authority normally is the authority of the "fire plan". The owner has the responsibility of operating and maintaining. While theoretically a harmonious interaction of these responsible parties should exist, the assignment of responsibilities has not historically been clearly defined.

"WHEN" - While the commissioning theoretically follows the construction and precedes the acceptance, practically the direction, the programming and some of the testing should occur during the construction period in order to allow for sufficient lead time for an orderly and complete overall systems testing, instructions and takeover. As the building operator is the essential party for operational modes, he is also essential for commissioning, and therefore he should be present before acceptance.

The question of "recommissioning" and the introduction of a "new" fire plan and assignment of responsibilities must be clarified for each occupancy change of a building.

COMMISSIONING

Discussion:

"HOW" - A work plan listing components, describing systems and interaction procedures, phasing and schedules with milestone dates and conditions of acceptance should be tabled defining duties and functions of each responsible party. Management of these functions is required to ensure safe, orderly occupancy at a prescribed date.

Test logs should be prepared by the contractors and submitted for approval by the authorities with due regard for time requirements. Test log formats should include identification for retesting of components and/or systems with proper time slots allocated for each outlined procedure. Copies of these test logs must be submitted to the permit-granting authorities.

Commissioning should include the preparation of maintenance instruction and requirements of retesting components listing frequency, test of active components and systems under normal operation (e.g., water pressures, level gauges), testing of components and systems activated only under emergency conditions (e.g., emergency generator systems, fire pumps), simulation tests of water systems, of dynamic smoke suppression and of exhaust purging systems and spot testing of non-active components such as fire hose, sprinkler heads. These should be as "standardized" as possible for easy reference by authorities, changes in building ownership and/or management.

Economic Impact:

While this would result in some perceived extra costs the effect of our earlier recommendations is to shelter buildings from any effect of this recommendation. The commissioning of a sprinklered building and a non mechanical pressurization of refuge measure is well known and relatively simple.

SMOKESHAFT VENTING

Recommendation:

Provide positive fan assisted exhaust venting when smoke shafts are used for venting to aid fire fighting.

Discussion:

Experience has shown that without the fan the downdraft of the cold shaft air (in cold weather) can overcome attempts to remove smoke from the floor.

We recommend that the fan be added and that the fan be located at the bottom of the shaft for maximum effect.

Economic Impact:

The impact of this recommendation is the additional cost of a fan when a smoke shaft is used. It should be noted that a smoke shaft is not mandatory and designers should be encouraged to utilize on floor horizontal venting which is much more reliable and economical.

APPENDICES

APPENDIX 'A'

FIRE EXPERIENCE STATISTICS
PROVINCE OF ONTARIO
(1976 - 1980)

The following summary of records for the years 1976 - 1980 was obtained with the assistance of the Office of the Ontario Fire Marshal.

The fire experience record of hotel, business and personal use, and mercantile occupancies in buildings classified under Subsection 3.2.6. is illustrated. The buildings, although classified under 3.2.6., for height in all probability, do not necessarily incorporate the requirements as many were constructed prior to 1975.

The record is a sampling to indicate the recent record in high buildings in Ontario.

SUMMARY OF FIRE STATISTICS 1976 - 1980

BUSINESS, PERSONAL USE & MERCANTILE OCCUPANCY (HIGH BUILDINGS)

	1976	1977	1978	1979	1980
No. of Incidents	39	39	19	32	29
No. of Incidents with Injuries and/or Death	3	-	3	3	1
Total Injuries	3	-	9	8	1
Total Deaths	-	-	-	-	-
Total Dollar Loss for all Incidents	449,321	84,676	544,488	562,596	144,645

FIRE STATISTICS FOR 1976

BUSINESS & PERSONAL USE OCCUPANCY

Yearly Total:

- Number of incidents: 30
- Two incidents with injury (2 injuries in total)
- Total dollar loss: $238,946.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 20 storey building
- Area of origin of fire: transformer vault including ancillary switch gear
- Extent of damage: confined to object or origin
- Source of ignition: transformer
- Dollar loss: None

Incident #2:

- 1 injury
- 21 storey building
- Area of origin of fire: service and equipment area - unclassified or unknown
- Extent of damage: confined to object or origin
- Source of ignition: electrical distribution equipment - unclassified or unknown
- Dollar loss: $5.00

FIRE STATISTICS FOR 1976

MERCANTILE OCCUPANCY

Yearly Total:

- Number of incidents: 9
- One incident with injuries (1 injury, total)
- Total dollar loss: $257,375.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 29 storey building
- Area of origin of fire: trash, rubbish area (including waste paper, industrial waste, garbage)
- Extent of damage: confined to floor area of origin
- Source of ignition: "Open" flames - unclassified or unknown
- Dollar loss: $100,000.00

FIRE STATISTICS FOR 1977

BUSINESS & PERSONAL USE OCCUPANCY

Yearly Total:

- Number of incidents: 34
- No incidents with injury or death
- Total dollar loss: $83,216.00

MERCANTILE OCCUPANCY

Yearly Total:

- Number of incidents: 5
- No incidents with injury or death
- Total dollar loss: $1,460.00

FIRE STATISTICS FOR 1978

BUSINESS & PERSONAL USE OCCUPANCY

Yearly Total:

- Number of incidents: 17
- 3 incidents with injury (9 injuries total)
- Total dollar loss: $544,363.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 6 injuries
- 27 storey building
- Area of origin of fire: office
- Extent of damage: confined to building of origin
- Source of ignition: smoker's materials
- Dollar loss: $450,000.00

Incident #2:

- 2 injuries
- 33 storey building
- Area of origin of fire: storage area - unclassified or unknown
- Extent of damage: confined to building of origin
- Source of ignition: miscellaneous - unclassified or unknown
- Dollar loss: $35,000.00

FIRE STATISTICS FOR 1978

BUSINESS & PERSONAL (continued)

Incident #3:

- 1 injury
- 20 storey building
- Area of origin of fire: electronic equipment room (includes computer, data processing room)
- Source of ignition: electrical distribution equipment - unclassified or unknown
- Dollar loss: $50,000.00

MERCANTILE OCCUPANCY

Yearly Total:

- Number of incidents: 2
- No incidents with injury or death
- Total dollar loss: $125.00

FIRE STATISTICS FOR 1979

BUSINESS & PERSONAL USE OCCUPANCY

Yearly Total:

- Number of incidents: 25
- 3 incidents with injuries (8 injuries total)
- Total dollar loss: $538,568.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 56 storey building
- Area of origin of fire: maintenance shop
- Extent of damage: confined to object of origin
- Source of ignition: motor - 1 HP and over
- Dollar loss: $25.00

Incident #2:

- 1 injury
- 13 storey building
- Area of origin of fire: office
- Extent of damage: confined to building of origin
- Source of ignition: electric wiring, cable
- Dollar loss: $110,000.00

FIRE STATISTICS FOR 1979

BUSINESS & PERSONAL (continued)

Incident #3:

- 6 injuries
- 24 storey building
- Area of origin of fire: electronic equipment room.
- Source of ignition: miscellaneous - unclassified or unknown
- Dollar loss: $300,000.00

MERCANTILE OCCUPANCY

Yearly Total:

- Number of incidents: 7
- No incidents with injury or death
- Total dollar loss: $24,028.00

FIRE STATISTICS FOR 1980

BUSINESS & PERSONAL USE OCCUPANCY

Yearly Total:

- Number of incidents: 25
- 1 incident with injury or death (1 injury total)
- Total dollar loss: $38,520.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 12 storey building
- Area of origin of fire: office
- Extent of damage: confined to floor area of origin
- Source of ignition: smoker's materials
- Dollar loss: $19,500.00

MERCANTILE OCCUPANCY

Yearly Total:

- Number of incidents: 4
- No incidents with injury or death
- Total dollar loss: $106,125.00

SUMMARY OF FIRE STATISTICS 1976 - 1980

HOTEL OCCUPANCY

(HIGH BUILDINGS)

	1976	1977	1978	1979	1980
No. of Incidents	53	44	53	64	52
No. of Incidents with Injuries and/or Death	4	7	3	5	4
Total Injuries	5	12	3	8	6
Total Deaths	-	-	-	-	2
Total Dollar Loss for all Incidents	68,617	442,236	88,059	216,798	276,125

FIRE STATISTICS FOR 1976

HOTEL OCCUPANCY

Yearly Total:

- Number of incidents: 53
- Four incidents with injuries (5 injuries total)
- Total dollar loss: $68,617.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 12 storey building
- Area of origin of fire: bedroom (under 5 occupants)
- Extent of damage: confined to part of room/area of origin
- Source of ignition: smoker's materials - unclassified or unknown
- Dollar loss: $6,000.00

Incident #2:

- 1 injury
- 43 storey building
- Area of origin of fire: bar, beverage area
- Extent of damage: confined to room of origin
- Source of ignition: electronic equipment - communications excludes data processing equipment (classified under 55)
- Dollar loss: $13,500.00

FIRE STATISTICS FOR 1976

HOTEL OCCUPANCY (continued)

Description of Incidents

Incident #3:

- 1 injury
- 43 storey building
- Area of origin of fire: bedroom (5 or more occupants)
- Extent of damage: confined to object of origin
- Source of ignition: smoker's materials - unclassified or unknown
- Dollar loss: $100.00

Incident #4:

- 2 injuries
- 16 storey building
- Area of origin of fire: Means of Egress - unclassified or unknown
- Extent of damage: confined to part of room/area of origin
- Source of ignition: cooking unit: portable (hot plate, camp stove, toaster, waffle iron, warming tray)
- Dollar loss: $700.00

FIRE STATISTICS FOR 1977

HOTEL OCCUPANCY

Yearly Total:

- Number of incidents: 44
- 7 incidents with injuries (12 injuries total)
- Total dollar loss: $442,236.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 2 injuries
- 26 storey office
- Area of origin of fire: display windows
- Extent of damage: confined to floor area of origin
- Source of ignition: miscellaneous - unclassified or unknown
- Dollar loss: $10,000.00

Incident #2:

- 1 injury
- 17 storey building
- Area of origin of fire: bedroom (under 5 occupants)
- Extent of damage: confined to floor area of origin
- Source of ignition: smoker's material - unclassified or unknown
- Dollar loss: $2,000.00

FIRE STATISTICS FOR 1977

HOTEL OCCUPANCY (continued)

Description of Incidents:

Incident #3:

- 1 injury
- 7 storey building
- Area of origin: lounge, sitting room
- Extent of damage: confined to part of room/area of origin
- Source of ignition: cigarette
- Dollar loss: $250.00

Incident #4:

- 3 injuries
- 27 storey building
- Area of origin of fire: large assembly area (or ballroom), non-fixed seats (over 60 people)
- Extent of damage: confined to building of origin
- Source of ignition: miscellaneous - unclassified or unknown
- Dollar loss: $265,000.00

Incident #5:

- 1 injury
- 26 storey building
- Area of origin of fire: hallway, corridor
- Extent of damage: confined to floor area of origin
- Source of ignition: miscellaneous - unclassified or unknown
- Dollar loss: $50,000.00

FIRE STATISTICS FOR 1977

HOTEL OCCUPANCY (continued)

Description of Incidents:

Incident #6:

- 1 injury
- 12 storey building
- Area of origin of fire: lounge, sitting room
- Extent of damage: confined to building of origin
- Source of ignition: cigarette
- Dollar loss: $10,600.00

Incident #7:

- 3 injuries
- 16 storey building
- Area of origin of fire: electronic equipment room (computer, data processing centre)
- Extent of damage: confined to part of room/area of origin
- Source of ignition: electrical distribution equipment - unclassified or unknown
- Dollar loss: $20,000.00

FIRE STATISTICS FOR 1978

HOTEL OCCUPANCY

Yearly Total:

- Number of incidents: 58
- 3 incidents with injury (3 injuries total)
- Total dollar loss: $88,059.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 8 storey building
- Area of origin of fire: washroom, locker room, checkroom or cloakroom
- Extent of damage: confined to building of origin
- Source of ignition: cigarette
- Dollar loss: $250.00

Incident #2:

- 1 injury
- 18 storey building
- Area of origin of fire: dining room
- Extent of damage: confined to part of room/area of origin
- Source of ignition: cooking unit: portable (includes coffee urn, steam table, etc.)
- Dollar loss: $200.00

FIRE STATISTICS FOR 1978

HOTEL OCCUPANCY (continued)

Incident #3:

- 1 injury
- 12 storey building
- Area of origin of fire: washroom, locker, cloakroom, checkroom
- Extent of damage: confined to floor area of origin
- Source of ignition: smoker's materials
- Dollar loss: $200.00

FIRE STATISTICS FOR 1979

HOTEL OCCUPANCY

Yearly Total:

- Number of incidents: 64
- 5 incidents with injury (8 injuries total)
- Total dollar loss: $216,798.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 1 injury
- 9 storey building
- Area of origin of fire: laundry area
- Extent of damage: confined to room of origin
- Source of ignition: miscellaneous - unclassified or unknown
- Dollar loss: $1,000.00

Incident #2:

- 3 injuries
- 17 storey building
- Area of origin of fire: large assembly area, non-fixed seats (over 60 people)
- Extent of damage: confined to part of room/area of origin
- Source of ignition: cooking unit - portable (hot plate, warming tray)
- Dollar loss: $250.00

FIRE STATISTICS FOR 1979

HOTEL OCCUPANCY (continued)

Description of Incidents:

Incident #3:

- 2 injuries
- 7 storey building
- Area of origin of fire: bedroom (under 5 occupants)
- Extent of damage: confined to building of origin
- Source of ignition: match (excluding smokers)
- Dollar loss: $17,000.00

Incident #4:

- 1 injury
- 10 storey building
- Area of origin of fire: bedroom
- Extent of damage: confined to room of origin
- Source of ignition: smoker's materials
- Dollar loss: $500.00

Incident #5:

- 1 injury
- 7 storey building
- Area of origin of fire: bedroom
- Extent of damage: confined to room of origin
- Source of ignition: cigarette
- Dollar loss: $1,000.00

FIRE STATISTICS FOR 1980

HOTEL OCCUPANCY

Yearly Total:

- Number of incidents: 52
- Number of incidents with injury and/or death: 4
- (6 injuries total, 2 deaths total)
- Total dollar loss: $276,125.00

Description of Incidents Involving Injury and/or Death:

Incident #1:

- 2 injuries
- 23 storey building
- Area of origin of fire: bedroom (under 5 occupants)
- Extent of damage: confined to part of room/area of origin
- Source of ignition: television, radio
- Dollar loss: $5,100.00

Incident #2:

- 1 injury
- 33 storey building
- Area of origin of fire: laundry area
- Extent of damage: confined to room of origin
- So rce of ignition: dryer
- Dollar loss: $2,050.00

FIRE STATISTICS FOR 1980

HOTEL OCCUPANCY (continued)

Description of Incidents:

Incident #3:

- 1 injury
- 37 storey building
- Area of origin of fire: kitchen, cooking area
- Extent of damage: confined to part of room/area of origin
- Source of ignition: cooking equipment - unclassified or unknown
- Dollar loss: $2,000.00

Incident #4:

- 2 injuries
- 2 deaths
- 9 storey building
- Area of origin of fire: hallway, corridor
- Extent of damage: confined to part of room/area of origin
- Source of ignition: "open" flames - unclassified or unknown
- Dollar loss: $276,125.00

APPENDIX 'B'

FIRE EXPERIENCE STATISTICS
BUILDING OWNERS AND MANAGERS ASSOCIATION OF NORTH AMERICA
(1981)

OFFICE BUILDINGS GREATER THAN 6 STORIES

		Percentages
Number of buildings	767	
Average number of stories	20.991	
square feet	338,332,258	
Number not sprinklered	258	33.638
Number fully sprinklered	128	16.688
Number partially sprinklered	381	49.674
Dollar value of capital add's	$ 66,322,456	
Dollar value of education	$ 4,669,863	
Number of buildings with fires	47	6.128
Number of fires this year	58	
Number of fires in sprinklered bldgs.	44	
Number of fires controlled by sprink.	8	18.182
Number of where area not covered by sprink.	24	54.545
Number where sprink. shut off	1	2.273
Number where fire not hot enough	9	20.455
Number of unknown reason for sprink. fail	2	4.545
Number of fatalities	2	
Number of non fatal injuries	6	
Number escape related injuries	0	0.000
Number fire related injuries	6	100.000
Number injured in hall	0	0.000
Number injured in tenant space	5	83.333
Number injured in elevator	0	0.000
Number injured in service areas	0	0.000
Number injured in other areas	1	16.667
Number of firemen injured	4	66.667
Number of tenants injured	0	0.000
Number of building staff injured	2	33.333
Number of smoke inhl. injuries	2	33.333
Number of burn injuries	4	66.667
Number of falling injuries	0	0.000
Number of other injuries	0	0.000
Number hospitalized less than 1 day	2	33.333
Number hospitalized 1 to 7 days	2	33.333
Number hospitalized 8 days to 1 month	2	33.333
Number hospitalized more than 1 month	0	0.000
Number of fires caused by smoking	8	13.793
Number of fires caused by electrical	17	29.310
Number of fires caused by mechanical	2	3.448
Number of fires caused by arson	7	12.069
Number of fires caused by careless workers	7	12.069
Number of fires caused by spontaneous comb.	6	10.345
Number of fires of unknown cause	6	10.345
Number of fires caused by other reasons	5	8.621
Number of fires started in garage areas	3	5.172
Number of fires started in tenant space	23	39.655
Number of fires started in elevator	1	1.724
Number of fires started in hallways	2	3.448
Number of fires started on exterior	3	5.172
Number of fires started in restrooms	1	1.724
Number of fires started in elec/mech rooms	8	13.793
Number of fires started in service areas	5	8.621
Number of fires started in basements	3	5.172
Number of fires started in other areas	9	15.517
Number of fires discovered by water flow	4	6.897
Number of fires discovered by smoke detector	10	17.241
Number of fires discovered by heat detector	3	5.172
Number of fires discovered by individuals	39	67.241
Number of fires discovered by other means	2	3.448
Number of times alarm system did work	34	58.621
Number of times alarm system did not work	4	6.897
Number of times alarm system was not needed	20	34.483
Average size of fire floor or area	25,631 square feet	
Average floor of origin	8.586	
Average number of floors above involved	3.483	
Average number of floors below involved	3.500	
Area damaged by fire	112,482 square feet	
Area damaged by water	47,325 square feet	
Area damaged by sprinklers	3,918 square feet	
Area damaged by smoke	320,956 square feet	
Average number of floors below damaged by H20	0.17	
Dollar damage caused by fires	$ 3,848,802	